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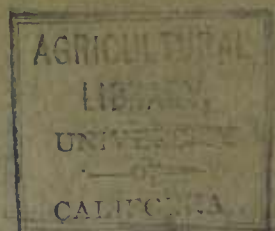
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THE POSSIBILITY OF EXTENDING WELL-IRRIGATION

IN



BIHAR AND CHOTA NAGPUR.

BY

N. N. BANERJEE, B.A., M.R.A.C., F.H.A.S., M.R.A.S.I.,

Department of Agriculture, Bengal.

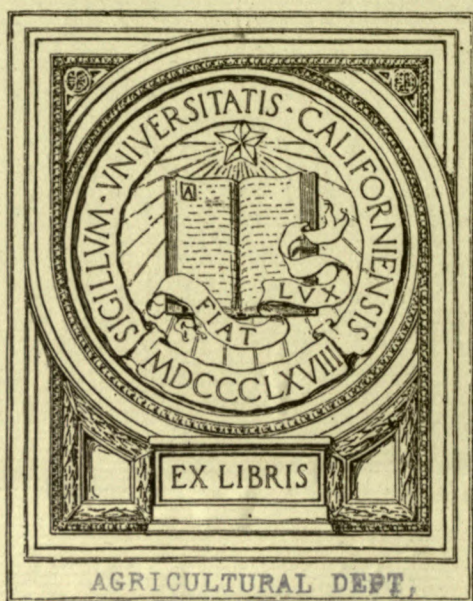


CALCUTTA.

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ON

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THE BENGAL SECRETARIAT BOOK DEPOT

1901



PREFACE.

—◆—

THIS Report deals with the possibility of extending well-irrigation in Bengal, being the result of the enquiry which was entrusted to me by the Government of Bengal under G. O. No. 2658, dated the 31st October 1905.

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REPORT

ON

THE POSSIBILITY OF EXTENDING WELL-IRRIGATION

IN

BIHAR AND CHOTA NAGPUR.

CHAPTER I.

IRRIGATION FROM WELLS.

Introductory.—Water is one of the necessary plant foods. It constitutes more than half of the material which makes up the dry matter of plants; and as water, it constitutes from three-fourths to more than nine-tenths of their gross weight.

The rainfall is the primary source of the subsoil supply of water, being that portion of the rainfall absorbed by the earth. The extent of this supply of subterranean water, and the great importance of wells as a source of irrigation in India may be gauged from the fact elicited by the Irrigation Commission, that 13 million acres of land are irrigated from wells in British territory. Even this large figure fails to indicate the extent of the stores underground. Indeed, it represents but an insignificant portion of the vast quantity of rain water which annually sinks into the earth and finally finds its way into the sea.

The collection and storage of the water thus allowed to go to waste, or, in other words, the feasibility of extending the construction of wells, is the subject-matter of this report.

In the Eastern districts of the United Provinces, much has been done in this respect. The number of wells that are being constructed, from which the subsoil water is applied to the *raiya*'s fields is steadily on the increase. Such is not the case, however, in Bihar where, although there is a close resemblance of conditions to those districts, well irrigation is not, on the whole, popular. In Chota Nagpur, the use of well water for irrigation is still more limited. The enquiries made by the Irrigation Commission pointed to the certainty that there was not a single Province in India, where well irrigation could not be extended with advantage. Well irrigation may not be useful for bringing the rice crop to maturity; but when there is not sufficient rain, it really constitutes the only means of successfully cultivating high class crops and is very beneficial for all *rabi* crops, so that when there is a failure of rice and an early cessation of the monsoon rains, with the help of this well water, the cultivators are enabled to reap a good *rabi* harvest, which compensates them to some extent against the loss sustained from a poor rice crop. There are many tracts in which the supply from canals is uncertain, and there are other tracts in which canal irrigation does not exist, and in which, if canals were constructed, they would probably be useless or even injurious to crops. In all such places, wells become necessary either to increase the production or to save the crops in times of drought.

When well water can be applied economically to lands, it has some distinct advantages over rain water. It can be applied at such times and in such quantities as is needed. This gives a certain amount of certainty to results, which it is impossible to obtain, where the result has to be dependent upon sufficient or insufficient, seasonable or unseasonable rain. Then again, well water used for irrigation contains, as a rule, larger percentages of both the organic and ash ingredients of plant food than rain water contains. These ingredients being held in a soluble form become at once available and thus stimulate plant growth.

In the case of Bengal itself, although there are no official statistics to indicate the extent of well irrigation in the Province, estimates made for the Irrigation Commission showed that whatever well irrigation existed in the Province was to be found only in Bihar and chiefly in West Bihar. There is a reason for this state of affairs. The rainfall of Eastern Bengal is so high, that it can be always depended upon for good rice crops and there is always sufficient moisture also in the soil for the cultivation of cold weather crops, so that the necessity for well irrigation is practically non-existent in this tract. This is not equally true of Bihar, where the rainfall is lower and extremely variable.

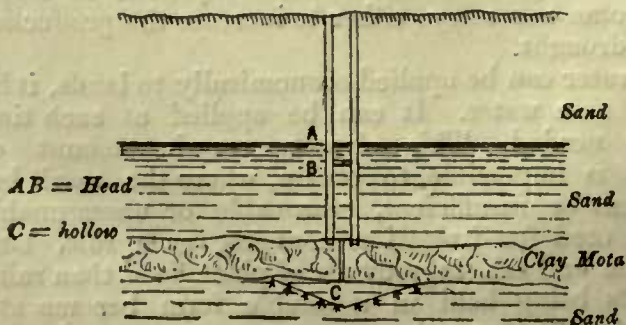
Even in Bihar, however, it was estimated that the area under well irrigation was less than .05 per cent. of the cultivated area. In the adjoining districts of Ghazipur, Ballia, and Gorakhpur, statistics show that the corresponding percentages amount, according to the *milan khasras* of these districts for 1904-05, to 22.6, 22.83, and 10.91 per cent., respectively. Now, in Bihar, whenever rice is grown, the crop often fails for want of suitable rain; and famine, severe at times, follows. The necessity for sinking wells, therefore, in these parts becomes an important question. In view of its importance, the present enquiry has been made in the Eastern districts of the United Provinces, in Bihar, and in some districts of Chota Nagpur with the object of determining how far it is possible to extend in these tracts of Bengal the practice of well irrigation, which is so largely resorted to, and which at the same time has proved a valuable resource in famine years in the United Provinces.

CHAPTER II.

CLASSES OF WELLS.

Spring and percolation wells.—Rain water penetrates into the soil according to the nature and level of the surface. Sometimes, it filters down only to small depths. In other cases, it forms reservoirs at considerable distances from the ground surface. Water is thus to be found at levels varying from a few feet, which makes well irrigation easy, to distances which render such irrigation impracticable or impossible.

According to the manner in which this subsoil water is received in wells, they are styled spring (Vern—*sota*, *bhur*) or percolation wells (Vern—*jharna*). In the case of spring wells, the water is obtained from underneath a stratum of clay or gravel mixed with sand which overlies the water-bearing stratum, which is generally sand. In percolation wells, the supply is obtained by percolation from the sandy sides and bottom, *i.e.*, from the stratum of water-bearing sand. In both cases, the well may be protected by a cylinder of masonry or other material. The hard bed of clay is known in the vernacular as the *mota* or *tawa*. It varies in thickness from 3 to 5 feet, or even to 10 feet and more. It is on this natural clay platform, that a well has to be embedded, if any good results are to follow. Water rises into the well when this platform is pierced. Tapping a good *mota* ensures a continuous supply of water, and ensures, too, the stability of the well. In new wells, when the *mota* is first pierced, a certain quantity of sand and water is forced up through the hole into the well, and a cavity is formed in the sand under the clay. The hollow is of the form C as shown in the following diagram:—



When there is a sufficiently thick *môta*, it acts as a safe platform to support the masonry work of the well over this cavity which, when, the well is worked, gradually enlarges, until its surface is sufficient to discharge a supply corresponding to the *head* given (the *head* being the difference of level between the water inside and outside the well). The emission of sand also ceases after a short time, when the *môta* is a good one, and the water rises gently into the well, quite pure and free from any admixture of sand. On the depth at which the *môta* is to be found depends the desirability or otherwise of sinking spring wells; for when it is very low down, it would make the cost of digging and of construction prohibitive. A percolation instead of a spring well should be used under such a circumstance. A percolation well also becomes a necessity when the *môta* does not exist at all.

Soil sections to be found in sinking wells.—The soil sections to be found in sinking spring wells vary considerably in different districts, as well as in different parts of the same district. There may be a sandy loam above and clay beneath. In some wells, no sandy loam may be found whatever, clay being situated at or above the percolation level. There might be sandy loam above and below, with a stratum of clay between.

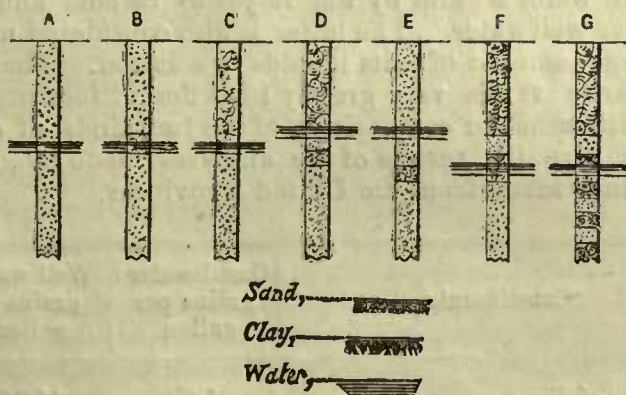
In percolation wells, on the other hand, deep layers of sand may be found, and this sand may be either coarse or fine. In the latter case, the construction of the well becomes difficult. In alluvial tracts, the different strata and substrata to be generally met with are:—

- (a) *Doras* or sandy loam.
- (b) *Kankar* or gravel.
- (c) *Karail* or a sticky clay.
- (d) *Piara* or a red clay.
- (e) *Balua* or sand.

These will be found at different depths and of varying thicknesses, occupying different positions with respect to each other. All, or only some of them, may be present, according to the situation and locality of the well.

In hilly tracts, the substrata consist of different kinds of rock.

Diagrams A to G below illustrate some conditions of sub-soil to be met with, but they may be indefinitely multiplied, as the clay, sand and water occupy every possible relative position:—



Masonry and earthen wells.—According to the materials used, wells may be classified as *pakka* (masonry) and *kachcha* (earthen). The former may be described as wells having a cylinder constructed of bricks, with or without lime and mortar, while earthen wells are merely holes dug into the ground without any such protection. They may be however lined with earthen rings or with coils of interwoven bamboo or twigs of different plants, such as *arhar*, *cotton*, &c. Where there are large areas to be irrigated and where the water-level is very low and the sides of the well are not very compact, it is necessary to sink masonry wells. In very compact soils, and also where water is found at a close distance from the ground and the areas to be irrigated are small, *kachcha* wells are suitable.

Before digging masonry wells, it should be ascertained whether there is a layer of clay, strong and thick enough to bear the weight of the brick cylinder, and whether this layer is situated sufficiently below the water-level; for if it is

not, the depression of surface would not be produced, which is necessary for a working head to ensure that the supply drawn into the well corresponds with the quantity taken out. The depth at which the *mōta* lies below the surface of the ground should also be ascertained. When very deep, the cost of digging and construction would become prohibitive.

In the sinking of earthen wells, the layer of clay must be found lying at a suitable depth below the water-level, and the water bearing stratum of sand must not be too thick, as the pressure of the sand would make the well fall in and choke it altogether. Such an accident should be provided against by a lining of some kind.

Saline and sweet wells.—Wells may be considered as of two classes, according to the chemical composition of their waters. Among cultivators, the broad distinction between *sweet* and *saline* water is very commonly known. Both are used for irrigation purposes, the suitability of the latter depending altogether upon the degree of salinity. While the water of so-called *saline* or *kharapani* wells is considered especially good for certain kinds of vegetables and also for tobacco, if the salts they contain exist in any excess, the well is considered unfit for cultivation. In my tours, I did not find a single such well in Bihar or Chota Nagpur; and in the United Provinces I came across only one well in Ghazipur, the water of which was considered distinctly injurious to crops. The analysis of this water is given below:—

Parts per 100,000.

Calcium nitrate	...	...	75.5
Calcium carbonate	...	...	.9
Magnesium carbonate	...	...	44.7
Magnesium sulphate	...	...	37.8
Sodium carbonate	...	...	...
Sodium chloride	...	...	49.5
Potassium chloride	...	...	11.9

In contradistinction to the *kharapani* or brackish water of wells is what the *raiya*s term *mithapani* or sweet water. Wells with this water are used for the irrigation of all kinds of crops, and when they are to be found in proximity of canals, their water is preferred to canal water, more especially for vegetable crops. Analyses of waters used for irrigation will be found in the Appendix attached to this report. Canal water is said by the *raiya*t to be cold and not so good for crops as the warmer well water. The latter is also considered more valuable on account of the large amount of salts it holds in solution. The composition of such water necessarily varies very greatly in different localities; but as giving some idea of the difference of composition of the two kinds of water, it will be interesting to add here the results of the analyses made by Dr. Vöelcker of samples of both kinds taken from the United Provinces.

Constituents.			Canal water : grains per gallon.	Well water : grains per gallon.
Sulphate of lime	...	...	1.80	10.71
Phosphate of lime	...	...	.13	1.59
Carbonate of lime	...	...	4.55	4.09
Carbonate of magnesia	...	...	3.52	13.23
Chloride of potassium	...	...	.63	.59
Carbonate of potash	...	...	.60	.....
Chloride of sodium	...	...	.....	14.69
Nitrate of soda	...	...	.....	8.66
Carbonate of soda	...	...	2.39	16.41
Oxide of iron and alumina	...	...	.28	.....
Soluble silica	...	...	1.26	1.96
Total solid residue per gallon	...	...	15.16	71.93
Free ammonia	...	...	.001	.002
Albuminoid ammonia	...	...	.007	.005

The well water was considered to be specially good for the tobacco crop and to be much superior to the water from the canal. The analyses above point out at once the marked difference in the amounts of solid constituents contained in the respective waters, the canal water having only 15 grains to the gallon against 72 grains to the gallon in the well water. The two waters differ chiefly in the soda salts present and in the nitrates, chlorides and sulphates. In his complete analyses of the above samples, Dr. Vöelcker shows that the canal water contained only 1.40 grains per gallon of soda, while the well water had no less than 20.53 grains per gallon of the same constituent.

CHAPTER III.

CONSTRUCTION OF WELLS.

Selection of a site.—Experienced cultivators know very well where good water is available and where the *mota* is situated, but a curious custom prevails among them of consulting Brahman priests and pandits, and men also of lower castes known as *shagunias*, before they enter upon the work of constructing masonry wells. The land-holders and larger cultivators generally consult pandits, while the poorer cultivators consult *shagunias*. There is more common sense displayed in the latter case, as *shagunias* are generally well-experienced cultivators, and can help less-experienced men in their selection. In the case of *kachcha* wells, there is no consultation, as priests, pandits and *shagunias* alike consider it beneath their dignity to be troubled in such a small matter. Very often, the prognostication of the *shagunia* is correct; as often as not, it is incorrect. But superstition and conservatism are so engraved in the minds of cultivators, that most of them must resort to this advice before they dig a well. Even Muhammadans take the advice of these Hindu *shagunias*, who not only fix the location of the well, but also say at what depth water is likely to be found, and to what depth the digging must go on, till the *mota* or *tawa* can be reached.

Season and time for construction.—*Kachcha* wells take only one to five days in digging. They are generally sunk towards the latter end of October, and in November and December, as they are required for the irrigation of cold-weather crops. The *raiya*t begin their digging in reality when their *rabi* sowings are completed. *Pakka* wells are dug from the end of January to the end of June. They take from a month to six months in construction. The best time to construct them is in the end of April or the beginning of May, which gives enough time for their completion before the setting in of the rains. Ordinary *kachcha* wells last only for a year; but when protected with earthen rings or twigs, they may last several years. *Pakka* wells may last a century, if they are well constructed and proper care is taken of them.

Cost of construction.—The cost of construction varies a great deal, being dependent upon many factors, such as the depth of the *mota* or clay foundation layer, the depth of the sub-soil water surface, the nature of the sub-strata, the size and kind of well to be constructed, the quality of the materials used, the amount and kind of labour available, and so on. No single estimate can therefore be accepted as a strict model upon which to work. Throughout my tours, many estimates were made, and from the many figures before me, I think I may well conclude that the cost of an ordinary shallow *kachcha* well varies from Re. 1 to Rs. 5. There are deep *kachcha* wells which cost Rs. 20 or Rs. 30. When *Koeris* dig their own shallow earthen wells, the well practically costs them nothing, as they do their own digging. Besides, small cultivators as a rule club together and dig their own wells, so that no actual cash expenditure has to be incurred. If twigs are used for lining, they do not cost more than a rupee; when earthen rings are used, their cost varies from Rs. 5 to Rs. 10, according to the depth of the well. In *pakka* wells, there is a much greater range in cost, because so much depends upon the different depths to which the wells have to be sunk, the strata which have to be dug through, and the quality and size of the cylinder constructed. Sometimes, most elaborate superstructures are made on wells by large land-holders, which cost a great deal of money. The figures taken by me show that the cost ordinarily varies from Rs. 80 to Rs. 300, but there are wells,

commonly to be seen, which cost from Rs. 500 to Rs. 800. When the superstructure is very elaborate, or where the well has to be sunk very deep into rock, instances have been quoted to me of wells costing Rs. 1,800 to Rs. 2,000.

The following may be taken as a fair probable average estimate of costs for a *pakka* well about 4 feet in diameter and about 35 feet in depth. A well of these dimensions has been selected for the estimate, as it is to be commonly found in most districts with an ordinary superstructure:—

	Rs.
Labour for digging	40
„ „ removal of sand and water	30
„ „ constructing the cylinder	70
„ „ wood and iron work (generally done by the village carpenter and village blacksmith on the usual village understanding)	5
Bricks for cylinder	70
Lime and mortar for cylinder	30
Cost of superstructure	20
„ „ tools and other appliances, such as buckets, iron bars, &c.	15
„ „ curb (the wood is often presented by the landholder)	10
Gifts given to Brahmans, and other miscellaneous expenses	10
Total	300

It would perhaps not be out of place to quote the estimated cost of a *pakka* well in the United Provinces, as drawn out in a Government printed note shown to me. The figures given are for a well, the cylinder of which was to be 6 feet in diameter, sunk 25 feet below the percolation level and built to a height of 2 feet above it:—

The items of expenditure shown are as follows:—

	Rs.	A.
Curb, with iron shoe	30	0
Masonry cylinder, 39 feet at Rs. 4-6-6 per foot	171	14
Sinking, 25 feet, at Rs. 3 per foot	75	0
Earthwork	10	0
Total	286	14
Establishment at 10 per cent.	28	11
Tools and plant at 5 „ „	14	6
Contingencies	20	1
GRAND TOTAL	350	0

Mode of construction.—The mode of sinking depends upon the kind of well to be sunk. The diameter of the well is regulated according to the amount of available sub-soil water, the amount of water required for irrigation, the cost of construction, and the position of the well with reference to the land to be irrigated. The depth of the well is required to be such that even in a year of drought, there will be sufficient water in the well for irrigation purposes. Four feet of water is considered to be about the minimum depth of the water that should remain in a well, so that a proper supply may be obtained by lifts. It is also considered that the water in a well should not fall more than 10 feet below the level of sub-soil water in a dry year, so that, all circumstances taken into account, the depth of the cylinder should be about 14 feet below the sub-soil water-level in a year of drought. When the *môta* is a good one, and is at a suitable depth, it is tapped by simply boring through it (*Vide* Diagram I); but when it is too thick for ordinary piercing, or if there is another layer of sand between it and the true *môta* underneath, then the *môta* can be reached by sinking a short shaft through the clay or sand (*Vide* Diagram II). In cases again, when the *môta* is very low down, and it is found impossible to take the cylinder right down to it, the *môta* may be reached by sinking a pipe from the bottom of the cylinder to the clay stratum (*Vide* Diagram III). In this case, it is necessary to plug the bottom of the cylinder between the pipe and the wall of the cylinder with concrete.

Diagram I.

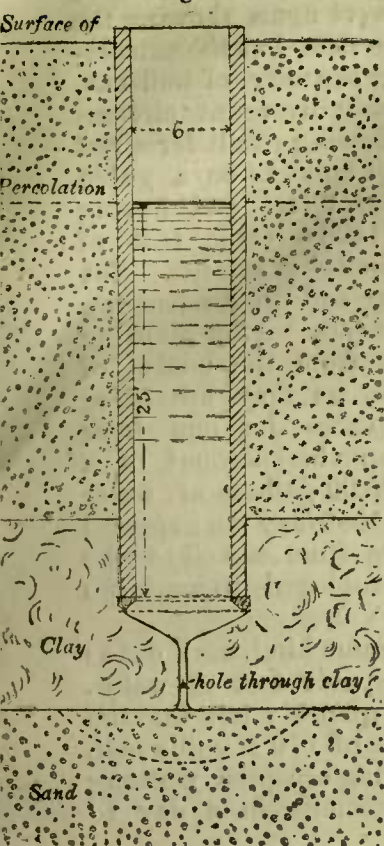


Diagram II.

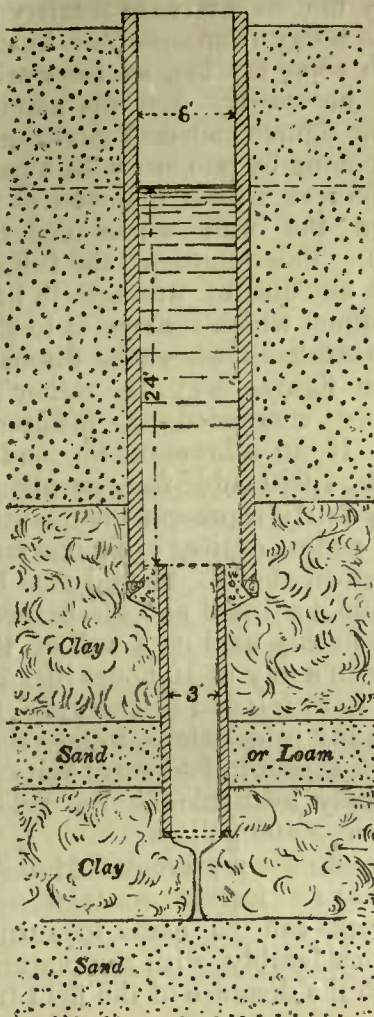
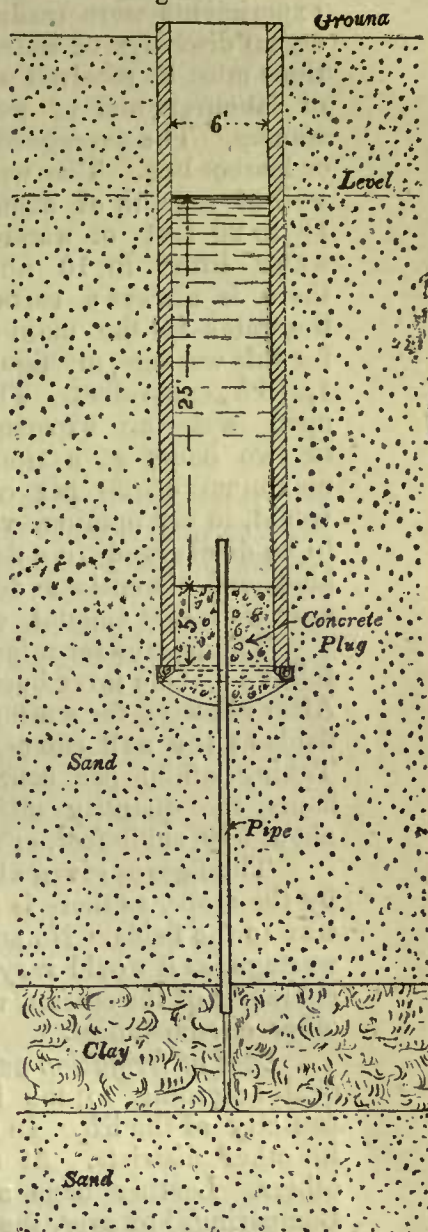


Diagram III.



REFERENCES.

Sand	-----
Water	-----
Concrete,	-----
Clay,	-----

In the case of *kachh* wells, digging is done down to the percolation level. If the sand is very loose, as has been already stated, it is found necessary to line the sides. In the case of wells built on the *môta*, the work of digging is continued down to the percolation level. The sand and water entering the well are removed; then a wooden curb (*jamot* or *putthi*) is let down on which the cylinder of the well is built. Round the outer rim of the curb is fixed a narrow sheet of iron projecting beneath the edge of the curb, which has the effect of sinking till it gets to a hard and stable stratum of earth, on which the cylinder can be supported. Now is commenced the masonry work. The curb is made of different kinds of timber. When the hard layer is reached, it is bored through for spring water by a long, heavy iron bar when water rises through the bore into the well at first mixed with sand and afterwards pure.

CHAPTER IV.

WATER-LIFTS AND THE WORKS DONE BY THEM.

It is not necessary to give any description of the methods of lifting water or of the different kinds of lifts in use, as they are well-known and have been described in many Government reports.

Amount of water lifted and discharged in a day.—A very large number of experiments were made by me to arrive at a fairly correct figure showing the actual discharge of water in a day from different kinds of lifts, but the calculations must be received with some caution, as the working capacity of bullocks, of labourers and of wells necessarily depends upon many divergent circumstances. The average of the figures collected gave the following result for a *mot* or leather bag. The work done by one *mot* with a pair of bullocks on a *pakka* well of a depth of about 35 feet with a diameter of about 7 feet and having 16 to 20 feet of water in the well works out to 1428·3 cubic feet of water lifted in 10 hours. This represents the full capacity of the lift. But there is always a certain amount of wastage in lifting and in discharging the water to the main channel which conveys it to the fields. After allowing for this wastage, my figures work to an actual discharge from the bucket of 1,276·5 cubic feet. These figures may be rather high, as they are based upon watering experiments conducted at different places for one hour or two hours at a time. If an allowance be made on this account of a maximum of 20 per cent., 1,020 cubic feet, or about 6,400 gallons of water would, in my opinion, very fairly represent the quantity that may be expected to be discharged in a day under ordinary circumstances, from a well of the kind and dimensions described above. Should men be employed to work the *mot*, a larger amount would be lifted and discharged.

The figures for a lever bucket used on a well of the same kind work out as follows :—One lever bucket in a day of 10 hours lifts 722 cubic feet of water. After allowing for wastage in lifting and discharging, the quantity left for the fields at the well comes, in my calculations, to an average of 679·4 cubic feet. Taking off 20 per cent. on account of waste of time during accepted working hours, the quantity ultimately available for the field amounts in a day to about 540 cubic feet, or about 3,400 gallons.

The figures given above do not represent the full amount of water received by the crops, as there is always a further wastage owing to soakage on the way to the fields. No attempt can be made to furnish an estimate of this wastage, as it would vary considerably with the nature of the soil, with the character of the season, with the distance of the field from the well, and many other circumstances.

Cost of irrigation per day.—The expenditure for irrigation varies a great deal according to the kind and quality of labour employed and the size and capacity of the lift. In some districts, labourers are more hard-working than in other districts. At some wells, better bullocks are to be found than at others. Leather bags and buckets vary a great deal *inter se* in their capacity. Comparing, however, the two kinds of lifts most commonly used for irrigation, viz., the leather bag drawn by cattle (*môt*) and the lever bucket worked by human labour (*dhenkal*), it is the opinion of most water-lifters that, roughly, two lever buckets would be necessary to do as much work as one leather bag. As far as I have been able to ascertain, I do not think watering with the lever bucket is of greater benefit than watering with the leather bag. When people can afford it, it is distinctly of advantage to finish the watering as soon as possible; and the leather bag does the work of the lever bucket in half the time. Further, where there is a flow of water of greater velocity, as in the case of the *môt*, there is less wastage in the water course. The *môt* system, as will be seen from the figures given below, is in reality as cheap, if not a little cheaper in fact, than the lever system. The cost of working per day under each system is as follows:—

Cost per day of working the môt by cattle.

(a) *Mot by cattle*—

				Rs.	A.	P.
Hire of a pair of bullocks	...	...	...	0	6	0
Wages of driver	...	...	...	0	2	0
" of one man for lifting and discharging water	...	...	...	0	2	0
" of one man for regulating the water in the field	...	...	...	0	2	0
Refreshment for labourers	...	...	...	0	0	6
Total	...	...	...	0	12	6

Cost per day of working the lever bucket.(b) *Lever bucket:—*

	Rs.	A.	P.
* Wages of two men at the well for lifting and discharging water	0	4	6
Wages of one man for regulating the water in the field ...	0	2	0
Refreshment for labourers	0	0	3
Total	0	6	9
Or for two lever buckets which may be regarded as equivalent to one <i>môt</i>	0	13	6

The lever bucket is, however, more suited to the pockets of the poorer agriculturists. Moreover, watering with it being a slower method than watering with the *môt*, it can be worked in comparatively shallower wells, which cost less to construct.

When the *môt* is worked by human labour, the cost per day is much more, as will be seen from the figures given below, but it must not be forgotten that the work done during the day is greater:—

(c) *Cost per day of working a môt by men.*

	Rs.	A.	P.
Wages of six labourers for the yoke	0	12	0
„ of three labourers as relieving men	0	6	0
„ of one man at well for lifting and discharging water ...	0	2	0
„ of one man for regulating the water in the fields ...	0	2	0
Refreshment for labourers	0	1	9
Total	1	7	9

Watering with the *môt* goes on at a quicker rate when men are employed, than when cattle do the work; but cultivators are not, as a rule, in favour of the system, as they prefer to do their cultivation work on the fields themselves.

Area irrigated per day.—Here also but an approximate estimate can be made, for the factors upon which this area should be determined vary a great deal *e.g.*, the area irrigated depends upon the character of the soil, upon the proximity of the field to the source of irrigation, upon the quality of labour available, etc. But under ordinarily favourable circumstances from the enquiries and observations made by me, I would fix the area to one-fourth of an acre, when the water is lifted by a *môt* worked by cattle. When the *môt* is worked by men, nearly double the area is irrigated. When the water is lifted by the lever bucket, one-eighth to one-tenth of an acre may be taken as a fairly approximate estimate. One-fourth of an acre would be a fair average area capable of being irrigated in a day from a *pakka* well, and one-tenth of an acre may be accepted as representing the average area capable of being irrigated from a *kachcha* well.

Area irrigable from wells.—From all reports and from enquiries made by me personally, I should say that the area irrigated by each permanent well in the districts visited by me averages 4 to 5 acres. Some wells do not irrigate more than an acre or an acre and-a-half, whereas there are individual wells which irrigate as much as 15 acres. A shallow *kachcha* well of a depth of 10 to 12 feet would irrigate about half an acre of land. A deeper well of 20 feet can irrigate from 2 to 4 acres. Two acres may be accepted as a maximum average.

* The wages of each man at the well has been taken at 3 pies more than that given to ordinary labourers on account of the heavier work entailed in lifting by the lever system.

Depth of watering.—The depth of watering can be obtained by dividing the volume of water raised and discharged in a day by the area irrigated during the same period. Taking the figures given above for the *môt* drawn by the cattle as a case for illustration, I find that the volume of water discharged in a day amounts to 1,000 cubic feet and the area irrigated is one-fourth of an acre. The depth of watering would therefore be:—

$$\begin{aligned}\frac{1,000 \text{ c. ft.}}{\frac{1}{4} \text{ of an acre.}} &= \frac{1,000 \text{ c. ft.}}{\frac{1}{4} \times 4,840 \times 9 \text{ sq. ft.}} \\ &= \frac{1,000}{10,890} \text{ feet.} \\ &= \cdot 0918 \text{ feet.}\end{aligned}$$

Of course, this depth would vary considerably with the crop to be irrigated. In experiments made in the United Provinces in 19 districts with different crops, it was found that the depths varied from $\cdot 0468$ feet up to $\cdot 2742$ feet.

The following results taken from Colonel Clibborn's reports on the construction of irrigation wells in the United Provinces show what figures may be accepted as the average of the depths of watering given to different crops:—

Name of crop.	DEPTH OF WATERING IN FEET.	
	First watering.	After watering.
Wheat	$\cdot 2500$	$\cdot 1860$
Barley	$\cdot 1860$	$\cdot 1860$
Tobacco	$\cdot 1860$	$\cdot 1250$
Opium	$\cdot 1860$	$\cdot 1250$
Carrots	$\cdot 1860$	$\cdot 1250$
Potatoes	$\cdot 1860$	$\cdot 1250$
„ (in ridges)	$\cdot 1250$	$\cdot 0930$
Garden produce	$\cdot 0930$	$\cdot 0930$
Sugarcane	$\cdot 2500$	$\cdot 2500$

It will be also seen from the above that the depth of the first and subsequent waterings hardly differ.

Comparing these depths of watering with the depths of watering in canal irrigation, Colonel Clibborn, who investigated the matter thoroughly in the United Provinces, came to the conclusion that water, when distributed from a well, is generally put on to just a sufficient depth and no more, but canal water, owing to the ease and cheapness with which it can be had, is often run on to an unnecessary extent. His investigations showed that rather more than three times as much water is used for irrigating an acre from a canal as from a well. The average depths of water used, as found by him, were $0\cdot 9$ inches ($\cdot 075$ feet) from wells and $2\cdot 86$ inches ($\cdot 238$ feet) from canals.

Amount of water needed for irrigation of different crops.—The crops watered from wells include almost all *rabi* crops. Wheat, barley and peas are more frequently watered than gram. Among *bhadoi* crops, maize and *marua* (*Eleusine coracana*) are occasionally irrigated and *cheena* (*Panicum miliaceum*) always. The special crops that require irrigation are sugarcane, opium, tobacco and potatoes with which may be included all kinds of vegetable crops (*bhadoi* and *rabi*).

The amount of water and the number of waterings needed for the irrigation of different crops vary within wide limits, being affected by the climate, weather, kind of soil, variety of crop, manner of application of the water, and by the character of cultivation which the field receives subsequent to irrigation. The amount of water needed for a single watering must be determined by the amount of water the soil contains at the time it is to be irrigated, and by the amount it should contain in order that plants may do their work to the best advantage.

As to the number of waterings necessary for each crop, confining myself only to well irrigation, my observations go to show that the figures given in the table below may be accepted as representing fairly accurately the number of waterings that are sufficient for crops given in the table:—

Name of crop.		Number of waterings.	Name of crop.		Number of waterings.
Maize	...	1 to 2	Gram	...	1
Marua	...	1 to 2	Poppy	...	6 to 10
Cheena	...	3 to 5	Sugarcane	...	5 to 10
Wheat	...	2 to 3	Tobacco	...	4 to 6
Barley	...	1 to 3	Potatoes	...	4 to 6
Peas	...	1 to 2	Vegetables	...	4 to 6

Subsidiary crops are given the same watering as the major crop.

CHAPTER V.

PHYSICAL, ECONOMIC, AGRICULTURAL AND IRRIGATIONAL CONDITIONS OF DISTRICTS VISITED: SUGGESTIONS FOR DEVELOPMENT OF WELL IRRIGATION.

General.—The information given up to this point may be accepted as generally applicable to all the districts of the United Provinces, of Bihar and of Chota Nagpur which are under review in this report. Undoubtedly, owing to difference of conditions in different districts, some of my remarks would require modification. In what direction such modifications may be necessary can be gleaned by a short study of the physical, economic, agricultural and irrigational conditions of each district. These conditions will now be considered, and my opinion then subscribed regarding the possibility of developing well irrigation in each district.

GHAZIPUR.

General description.—No hills of any kind are to be found in the district but there are upland and low-lying tracts both to the north and south of the district. The general level of the uplands is from 10 to 20 feet above the highest, and from 50 to 70 feet above the lowest level of the Ganges. The low-lands consist of *dhara* lands, which are under flood water every year. The uplands, which comprise about two-thirds of the district, are under good cultivation. The soil is fertile, and there is very little waste land in this tract. The *rabi* crops here, which in ordinary seasons are very good, are always grown with irrigation chiefly from wells. In the uplands, a considerable area of land is also under rice, which is grown with irrigation from *nullahs* and other depressions. The low-land alluvial portion of the district may also be subdivided into two parts, viz., the higher portion, which is liable only to occasional floods and which is exceptionally fertile, and the very low-lying lands deposited by the Ganges, which in years of scanty rainfall produce rice, or *rabi* cereals.

The soils of the district may be thus classified, and this classification may be accepted generally for Ballia and Gorakhpur also:—

- (1) *Balua*.—A light sandy soil in which sand predominates above clay.
- (2) *Doras*.—A mixture of sand and clay in about equal proportions.
- (3) *Matyar*.—A clayey loam in which clay is found in a larger proportion than sand.
- (4) *Karail*.—A black soil of a stiff clayey nature which cracks and fissures in the hot weather.

Irrigation is carried out on all the above soils except the last, which is very retentive of moisture, and without irrigation produces most excellent *rabi* crops, especially peas and gram.

Rainfall.—The normal rainfall of the district is reported to be about 40 inches. The rainfall for each year for the last ten years is shown in the sub-joined table:—

Rainfall for the calendar years 1896 to 1905.

Year.		Actual fall in inches.	Year.		Actual fall in inches.
1896	...	24 02	1901	...	28 01
1897	...	50 76	1902	...	35 20
1898	...	55 40	1903	...	42 69
1899	...	46 14	1904	...	50 31
1900	...	39 09	1905	...	46 73

From the figures above, it will be seen that there are great differences between the actual falls of different years, varying within the ten years from 24 02 inches in 1896 to more than double this amount (55 40 inches in 1898. The table further shows that the years of insufficient rain were 1896-97 and 1901-02. These were the years of famine and scarcity, an account of which will appear in a subsequent paragraph. The chief periods in which rain is required are the latter half of June for *bhadoi* crops generally, in July and August for rice, and in the latter end of September and in October for *rabi* crops which occupy about two-thirds of the area of the district. These *rabi* crops occupy, for the most part, the uplands of the district, where irrigation is ordinarily necessary, and when in a year of drought the necessity of irrigation becomes emphasized. Well irrigation at such times is most acceptable and is very largely resorted to. It will be gathered from the above remarks, that the construction of wells assumes a very important aspect in Ghazipur.

Population, material condition, emigration.—According to the Census Report of 1901, the population of the district amounted to 913,818 souls. The area of the district according to the same report is 1,391 square miles, so the density of population is 657 persons per square mile.

In the same Census Report, the total number of agriculturists is given as 646,933 souls. This would give a percentage of 70·79 on the total population.

The total area under cultivation being shown as 963 square miles, the density of the agricultural population would amount to 67 0 persons per square mile of total cultivated area.

Famine, scarcity, drought, &c.—Ghazipur enjoys comparative immunity from drought. It has gone through years of scarcity and high prices, but has always shown its ability to withstand famine. In the Settlement Report of the district, it is stated that “none of the extreme effects of famine have been known to occur within the period of one hundred years for which we possess more or less information.” Even in the year 1896-97, when deficiency of rain brought about a famine in many districts, no relief works were found necessary for the people of Ghazipur. Government gave help only with liberal *takavi* advances for seed and for construction of agricultural works of improvement. Much good was done by these advances, as zamindars and tenants were stimulated to dig wells in large numbers, and the area sown with *rabi* was thus greatly increased, to the relief of the district. In all, 4,763 *kachcha* wells were sunk in the district. There are no “precarious tracts” in Ghazipur. Agricultural conditions are more or less identical over the entire district owing to the absence of canal irrigation, so that when the pinch of a bad season is felt, it is felt equally all over the district.

Cultivation.—In the *milan-khasra* for 1904-05, the total cultivated area is shown as 619,361 acres. The total area of the district being 890,992 acres, the proportion of cultivation to the total area amounts to 69½ per cent. This cultivation is made up of crops which, in the United Provinces, are classified under three heads, viz.

- (a) *Kharif* crops, sown from the 15th June to the 15th July, and harvested from the end of September to the end of November;
- (b) *Rabi* crops sown from the 15th October to the 15th November and harvested from the end of March to the end of April, and
- (c) *Zaid* crops sown in March and in the beginning of April and harvested in the first-half of May.

The *kharif jinswar* (crop statement) comprises the following crops :— Rice (early and late), maize, *juar*, *bajra*, *arhar*, *marua*, *kodo*, *sawan*, *urid*, *mung*, *moth*, *guar*, *kurthi*, *arhar*, cotton, *sunh* hemp, *til*, indigo, sugarcane, spices, vegetable and garden crops and some minor miscellaneous food and non-food-crops. In the *rabi jinswar* are found wheat, barley, oats, gram, peas, *masur*, *latri*, *sarson*, *lahi*, linseed, opium, tobacco, spices, dyes, potatoes, vegetable and garden crops and other miscellaneous food and non-food-crops.

The *zaid jinswar* comprises melons, *cheena*, vegetables, spices, and other food and non-food-crops.

These *jinswar* statements for the year 1904-05 show 360,880 acres under *kharif*, 425,584 acres under *rabi*, and 1,744 acres under *zaid* crops, which come respectively to 58·27 per cent., 68·71 per cent., and ·28 per cent. of the net area under cultivation.

In these areas, the further following divisions may be noted in reference to irrigation requirements :—

Crop.	Area in acres.	Percentage to net cropped area.
<i>Kharif.</i>		
Total food-crops (including rice) ...	321,365	52·86
Total non-food-crops (including sugarcane).	33,515	5·41
Rice	153,577	24·80
Sugarcane	26,822	4·17
<i>Rabi.</i>		
Total food-crops	397,571	64·19
Total non-food-crops	28,013	4·52
Opium	15,460	2·49

N.B.—Rice, sugarcane and opium are shown separately, as they have an important bearing on irrigation.

It will be seen from the figures given above, that *rabi* crops are all important and that, unlike Bihar and Chota Nagpur, rice holds a comparatively insignificant place in the harvests of the district.

It is this variety of crops, both in the *kharif* and *rabi* harvests, that secures for Ghazipur immunity from famine. Sugarcane and opium occupy comparatively large areas, when contrasted with the areas under these crops in Bihar and Chota Nagpur.

Irrigation.—According to the *milan-khasra* of 1904-05, the net cultivated area of the district amounts to 619,361 acres, and the total irrigated area to 203,695 acres. The irrigated area thus forms 32·88 per cent. of the area under cultivation. There are no canals in the district. Water for irrigation is obtained from drainage channels, swamps, tanks and wells. The percentage of irrigation from each of the above sources will be seen from the following figures obtained from the above *khasra* :—

			Acres.
Area irrigated from tanks, &c.	...	...	63,303
Area irrigated from wells	...	...	140,392

Percentage of irrigation to net cultivated area—

			per cent.
(a) From tanks, &c.	...	...	10·22
(b) From wells	...	...	22·66

Wells, it will be seen, play the most important part in the irrigation of the district.

Cultivators do resort to streams, swamps and tanks, but the supply from these sources is limited, the water in them drying up as a rule by the middle of December. And the well system is steadily getting more and more popular every day. In the last Settlement Report of the district, it was noticed that at the time of Settlement the number of wells rose to 14,423 from 7,299 at

the previous Settlement. In the year 1904-05, the number stood at 18,765. Of these, 15,423 were masonry wells and 3,342 earthen wells.

The crops chiefly watered from wells in Ghazipur, as in other parts of the United Provinces and in Bihar, are *rabi* crops, and such special crops as sugarcane, tobacco, opium, vegetable and garden crops. Among *zaid* crops, *cheena* may be mentioned. Well water is considered by many of the cultivators to be more beneficial than tank or rain water. We find that in the case of special crops like sugarcane, opium, tobacco, and vegetable crops, practically the whole area is irrigated, as will be seen from the following district figures for 1904-05:—

Crop.	AREA IN ACRES.	
	Irrigated.	Unirrigated.
Sugarcane	25,697	125
Tobacco	305	7
Opium	15,454	Nil.
Potatoes	911	Nil.

As regards other crops, the subjoined table will be found useful as an indication of the extent to which they are irrigated:—

Crop.	AREA IN ACRES.	
	Irrigated.	Unirrigated.
Wheat	8,782	1,388
Wheat and gram	377	32,120
Barley	96,427	35,527
Wheat and barley	4,759	3,450
Peas	59,292	30,799
Gram	3,030	31,908

This also applies to market gardening, but taking the *rabi* area as a whole, a great portion yet remains to be irrigated. From statements examined by me in the Sadr Kanungo's office, I find that *rabi* food-crops, which are the principal crops that require to be watered from wells, and which occupy nearly 95 per cent. of the total *rabi* area, have still 60 per cent. of their area left unirrigated. This will show that, despite the steady increase in well-sinking, which has been going on for many years, the district is in reality still in want of irrigation. This is in fact the opinion of the people of Ghazipur.

No authoritative figures are forthcoming regarding the outturn obtained from irrigated and unirrigated areas, but from numerous village-to-village enquiries and from information obtained by me from *patwaries*, *kanungos* and others having a knowledge of agriculture, I offer for acceptance, though with much diffidence, the figures given below as mere approximations to the truth:—

Crop.	OUTTURN PER ACRE IN STANDARD MAUNDS.	
	Irrigated from wells.	Unirrigated.
Wheat	15	8
Barley	17	9
Gram	12	8
Peas	15	8

Well-irrigation in estates under the control of Government—The Court of Wards' Estates in the district occupy an area of 40,000 acres. In these estates, the disbursements made for wells during the last ten years is given in the following table:—

Year.				Amount. Rs.
1895-96	...	...	...	Not available.
1896-97	...	...	...	1,023
1897-98	...	...	...	316
1898-99	...	...	...	372
1899-00	...	...	...	2,567
1900-01	...	...	...	1,505
1901-02	...	...	...	59
1902-03	...	...	...	Nil.
1903-04	...	...	...	499
1904-05	...	...	...	249

BALLIA.

General description.—Ballia, which once formed a part of the Ghazipur district, has an area of 1,249 square miles. As in Ghazipur, the broad agricultural division is the lowland and the upland tract. The former lies near the Ganges, Gogra and Sarju, a smaller river which joins the Ganges near the town of Ballia, and from this low level, the land gradually rises towards the uplands. The lowlands are altogether the formation of the larger rivers. Unlike the *diara* lands of Ghazipur, they may be distinctly divided into two different classes in respect of their fertility. The *diara* lands formed by the Ganges are distinctly fertile. Here may be seen most luxuriant *rabi* crops, as in the *diaras* of Ghazipur affording a striking contrast to the same crops grown on the *diaras* of the Gogra, which fall far behind the Ganges crops in fertility. The reason of the difference is that the Gogra deposits a great deal of sand, while a fertile silt is deposited by the Ganges. The uplands are very similar to the uplands of Ghazipur. In the middle of the uplands, there is a regular depression right through the district. There are *jhals* in this depression. The soils are exactly similar to those found in Ghazipur.

Rainfall.—The normal rainfall is about the same as that of Ghazipur. The actual rainfall of the district for the last ten years is shown below:—

Rainfall for the calendar years 1896 to 1905.

Year.			Actual amount of rainfall.	Year.			Actual amount of rainfall.
1896	...	...	26.24	1901	...	...	32.98
1897	...	...	43.76	1902	...	...	40.58
1898	...	...	57.44	1903	...	...	39.60
1899	...	...	57.73	1904	...	...	44.44
1900	...	...	39.60	1905	...	...	45.92

From the above figures, it will be seen that the conditions of rainfall in Ballia are very similar to those of the Ghazipur district. There occur the same variations in the amount of rain received in different years.

Population, material condition, emigration.—In the Census Report of 1901, the total population is shown as 987,768, the area of the district as 1,249 square miles, and the density of the population as 791 per square mile, which is higher than in Ghazipur. The total number of agriculturists is shown as 659,668, so that the percentage of agriculturists to the total population is 66.8. This is slightly lower than the percentage in Ghazipur (70.79 per cent.).

The total cultivated area in the district is 552,948 acres. This would give a density of population of 763 persons per square mile of cultivated area, which is higher than that of Ghazipur (670 persons per square mile). The general condition of the cultivating classes is good. Many of them are very well off. As a rule, they are laborious, and perhaps a little more enterprising

than the people of Ghazipur. The *Koeris*, *Kurmis*, *Nunias* and *Bhuinhars* are more enterprising and energetic than the other castes. There is practically no emigration from the district.

Famine, scarcity, drought, &c.—Like Ghazipur, the district is free from famines, no famine having been recorded for the last century. It is however liable to floods and water-logging, over the whole of the low lying alluvial tracts, and in portions of the uplands; but the system of agriculture is suited to these occurrences, and the risk is serious only if the floods rise to a quite exceptional height, or last so long as to delay *rabi* sowings. In a printed note of the Agricultural Department, United Provinces, it is reported that there has been no instance of such delay during the last decade.

Cultivation.—The percentage of cultivated area on the total area of the district is 69·8, *i.e.*, practically the same as that in Ghazipur. The crops grown in Ballia are the same as in Ghazipur. The areas occupied by the three harvests and their proportion to the net cropped area are given as follows:—

Crop.			Area in acres.	Percentage to not cultivated area.
(1) Kharif	...	...	233,123	60·24
(2) Rabi	...	...	383,363	69·33
(3) Zaid	...	...	3,245	0·59

Of the *kharif* crops, rice occupies 19·32 per cent. of the net cropped area, all food-crops (including rice) 52·94 per cent., and all non-food crops 7·30 per cent. Sugarcane, which is included in the United Provinces *kharif jinswar*, occupies 38,917 acres or 7·04 per cent. of the total area. The *rabi* food-crops take up 67·32 per cent. of the cropped area, and *rabi* non-food crops 2·01 per cent. Opium is sown over a very small area (2,811 acres). The statistics above show that the cultivation of Ballia is very similar to that of Ghazipur. Rice in Ballia is an unimportant crop, and *rabi* forms the chief harvest. The sugarcane area of Ballia is larger than that of Ghazipur.

Irrigation.—The area under irrigation is given in the *milan khasra* of 1904-05 as 179,915 acres or 32·54 per cent. of the net cultivated area, which is practically the same as in Ghazipur. The same causes which operate in Ghazipur to make well-irrigation popular, prevail also in Ballia. From the *milan khasra* figures which follow, it will readily be seen that wells form the chief source of irrigation, the proportion of this system of irrigation being slightly higher than in Ghazipur even—

				Acres.
Net cultivated area	...	...	...	552,948
Area irrigated from tanks, &c.	...	...	...	43,625
„ „ „ wells	...	...	...	136,290

Percentage of irrigation to net cultivated area—

				Per cent.
(a) From tanks, &c.	...	...	...	7·8
(b) From wells	...	...	...	22·83

As in Ghazipur, the number of earthen wells (6,451) is much smaller than that of masonry wells (11,768), and the area irrigated from them is necessarily comparatively insignificant. I find there is one masonry well for every 11½ acres of land irrigated by wells, and one for every 46·9 acres of net cropped area. I feel quite sure from enquiries made in villages that there is still great room for well-irrigation in Ballia, and this is confirmed by figures which appear in the *rabi jinswar* statement for 1904-05 from which the total unirrigated area (238,896 acres) is found to be nearly double of the total irrigated area (144,467 acres). As in Ghazipur, special crops, such as sugarcane, tobacco, opium and

vegetable crops, are nearly all irrigated, as will be seen from the following figures :—

Crop.	AREA IN ACRES.	
	Irrigated.	Unirrigated.
Sugarcane	33,912	5,005
Tobacco	424	3
Opium	3,803	8
Potatoes	1,488	12

Almost all kinds of *zaid* crops receive irrigation. The extent to which some of the other crops receive irrigation will be seen from the figures below—

Crop.	AREA IN ACRES.	
	Irrigated.	Unirrigated.
Wheat	4,684	2,762
Barley	45,879	41,631
Peas	50,678	45,632
Gram	7,199	30,254

Outturn from irrigated and unirrigated areas.—It would be useful to give here figures showing the outturn of some of the principal crops of the district watered from wells, as contrasted with their outturn when no irrigation is given. These figures do not represent the actual averages or produce, but they are estimates which have been very carefully prepared by the Agricultural Department of the United Provinces. They are based on the experience of the quinquennial period ending 1901-02, as well as on the experience of former years, and are really estimates of the outturn that may be expected in a year of average character. It is not stated in the report that the source of irrigation is well-water, but the crops which appear below are those which are watered from wells :—

Name of crop.	Years for which figures are quoted.	OUTLINE PER ACRE IN LBS.	
		Irrigated.	Unirrigated.
Wheat ... {	1892	1,230	656
	1898-1902	1,250	750
Barley ... {	1892	1,538	738
	1898-1902	1,300	800
Gram ... {	1892	984	656
	1898-1902	950	700
Peas ... {	1892	1,312	656
	1898-1902	1,200	650

It will be seen from the above, that wheat and barley, which are most important crops in Ballia, have their outturn nearly doubled by irrigation. This coincides with the result of enquiries made by me personally. Peas give the same result. Gram does not benefit as much from irrigation as other *rabi* crops. Only one watering is given to it, and in many parts, it is grown without irrigation. The outturn nevertheless is enhanced even by the sprinkling of water that the crop gets.

GORAKHPUR.

General description.—Gorakhpur, unlike Ghazipur and Ballia, has no river boundary, and it is under temporary settlement. The total area according to the latest *milan-khasra* is 4,529 square miles. The district in general is a level plain, there being only a few sand hills in the centre and south-east.

The general slope is from the north-west to the south-east, the northern tracts lying almost at the foot of the Nepal hills. This is really the *Terai* of the district, and large tracts here are covered with valuable *sál* forests. There is a small tract of low-lying land on the west and south-west, which is inundated during the rains. Here, no autumn crops are grown, but the spring crops are generally very good. The map of Gorakhpur shows a net work of drainage lines and rivers. Hill streams intersect the north of the district, and larger rivers are found towards the south and south-west, which in the rains connect with each other and with the many *jhils* and lakes of the country, which contain the drainage of the district and form altogether quite an inland sea of water. The lands along the banks of the hill streams are more elevated than those further off, which are generally low and flat, and on which winter rice luxuriates with the water received for its irrigation from the rivulets.

The numerous rivers, streams, *jhils* and lakes ensure an abundant supply of water, and the moisture in the soil gives a general green appearance to the country, which presents a striking contrast to the country south of the Gogra.

The great rivers of the district divide it into three noticeable *doabs*, viz., (i) the eastern *doab*, which lies between the Chota Gandak on the west and the Gandak on the east; (ii) the central *doab*, which is situated between the Rapti on the west, the Chota Gandak on the east, and the Gogra on the south; and (iii) the south-western *doab*, which comprises the land between the Rapti on the north and east, and the Gogra on the south.

Rainfall.—The rainfall is heavier in the northern parts near the Terai than in the south.

The figures given in the subjoined statement are a record of the actual rainfall of the district for the years 1895—1905:—

Rainfall for years 1895—1905 (inclusive).

Year.		Actual amount of rainfall in inches.	Year.		Actual amount of rainfall in inches.
1895-96	...	39.5	1900-01	...	...
1896-97	...	28.3	1901-02	...	37.84
1897-98	...	...	1902-03	...	39.86
1898-99	...	...	1903-04	...	64.96
1899-00	...	66.92	1904-05	...	53.91

*Not available.

It will be seen from the above figures that the rainfall is very variable. There is also much variation in the distribution of rainfall over the different *tahsils* of the district. The normal fall is about 49 inches.

Population, material condition, emigration.—According to the Census of 1901, the total population was 2,957,074, the total area 4,596 square miles, and the density of population 643 per square mile. The total area under cultivation is reported to be 2,070,405 acres. With the total number of agriculturists standing at 1,128,823 souls, the density of the agricultural population, with reference to the cultivated area, amounts to 349 persons per square mile. The above statistics further show that agriculturists form only 38.17 per cent. of the total population. These figures clearly indicate deficiency of agricultural labour in the district, especially when compared with Ghazipur and Ballia, a result due no doubt to the physical character of the country.

The people appear to be less intelligent and at the same time lazier than those living in the west of Ghazipur and Ballia. Their condition is less prosperous than the people of these two permanently settled districts. In the south, however, they are more advanced than in the north.

Labour is more plentiful now, than it was a few years ago, and the condition of the cultivators is said to be improving yearly.

There is practically no emigration. In 1904-05, only 871 emigrants were registered.

Famine, scarcity, drought, &c.—The district may be said to enjoy comparative immunity from drought. Excepting a portion of the northern tracts, where means of irrigation are still limited, the entire area of the district is fairly well supplied with both natural and artificial irrigation, which are considered sufficient to avert drought in ordinary years, though they are unable to cope with a lengthy break in the monsoon.

Cultivation.—The percentage of the cultivated area on the total area comes to 71·15, which is just a little higher than that of Ghazipur and Ballia. But while cultivation is extensive, labour is scarce.

The crops are the same as those found in Ghazipur and Ballia. The area under each class with the percentage on the net cropped area is shown below:—

Crop.	Area in acres.	Percentage to net cropped area.
(1) Kharif	1,505,907	73·01
(2) Rabi	1,276,814	61·90
(3) Zaid	17,510	·85

Rice occupies 44·58 per cent. of the net-cropped area, sugarcane 4·19 per cent., all *kharif* food crops 67·44 per cent., and all non-food crops 5·57 per cent. The percentages of *rabi* crops on the net cultivated area are as follows:—*Rabi* food crops 53·76 and *rabi* non-food crops 8·14 per cent. Opium occupies an area of 14,592 acres, which is ·71 per cent. of the net cropped area.

Irrigation.—The net cropped area of the district is 2,062,680 acres and the total irrigated area 519,991 acres, so that the proportion of the latter to the former is 25·2 per cent. The figure is lower than that for Ghazipur or Ballia. It is the opinion, however, of many persons, I have consulted in the district, that Gorakhpur does not suffer for want of irrigation. Statistics of irrigation obtained from the *khasra* statements of the three Eastern districts of the United Provinces show that the percentage of irrigation from wells, with reference to the net cropped area in Gorakhpur (10·9 per cent.), is much less than the corresponding percentages in Ghazipur (22·66 per cent.) and Ballia (22·83 per cent.), but the irrigation from streams and tanks is more extensive as will be seen from the following figures:—

Percentages of irrigation from tanks, streams, &c., with reference to the net cropped area.

(1) Ghazipur	10·22 per cent.
(2) Ballia	7·8 „
(3) Gorakhpur	14·29 „

The total number of wells in the district is returned as 45,630, of which 32,133 are masonry and 13,497 earthen wells. The net cropped area being 2,062,680 acres, there is one masonry well to every 64·1 acres of this area. Taking next the crops that generally require well-irrigation, I give below figures showing the proportion of their irrigated and unirrigated areas:—

Crops.	AREA IN ACRES.	
	Irrigated.	Unirrigated.
Total <i>rabi</i> food crops	453,689	655,327
Sugarcane	45,489	41,053
Tobacco	234	83
Opium	12,086	2,506
Potatoes	2,453	733
<i>Zaid</i> crops	12,277	5,223

Special crops like sugarcane, opium and tobacco, and vegetable crops, e.g., potatoes receive their full measure of irrigation, but other crops do not, as may be gathered from the following figures:—

Crop.			AREA IN ACRES.	
			Irrigated.	Unirrigated.
Wheat	...	...	92,475	77,789
Barley	...	...	32,263	94,811
Peas	...	...	155,718	113,615
Gram	...	...	6,427	69,153

Outturn from irrigated and unirrigated areas.—As regards the yield produced by different crops with and without well-irrigation, I am able to supply estimates only, which must not be regarded as having any great claim to accuracy. They are the best figures I can furnish, and have been arrived at after much thought, from the result of the numerous enquiries, I have made in the district. The estimated outturns are:—

Crop.			OUTTURN PER ACRE IN MAUNDS.	
			Irrigated.	Unirrigated.
Wheat	...	...	15	8
Barley	...	...	17	9
Gram	...	...	12	10
Peas	...	...	15	8

SARAN.

General description.—The district of Saran is very similar in its situation and climatic conditions to the adjoining district of Ballia in the United Provinces.

Different kinds of soils are found distributed over the district, all of an alluvial nature. It is not necessary to note their different characters. There is the broad distinction between *bhat* and *bangar* lands, *bhat* being the high lands which predominate in the north of the district, and which generally produce two crops in the year, and *bangar* the low-lying rice lands which are found scattered all over the district.

In this last respect, Saran differs from Muzaffarpur, Champaran and Darbhanga, where *bangar* is confined chiefly to one distinctive tract.

Rainfall.—The normal fall of the district is 45·04 inches which is the lowest in North Bihar. The average rainfall which the district has received annually for the last ten years is shown in the following table:—

Year.	Actual fall in inches.		Year.	Actual fall in inches.	
1896	...	23·08	1901	...	36·37
1897	...	50·03	1902	...	37·53
1898	...	52·10	1903	...	35·07
1899	...	62·86	1904	...	49·07
1900	...	34·02	1905	...	54·33

It will be seen, that the range in the fall is very wide and it is this variation that necessitates provision for irrigation.

Population, material condition, emigration.—The last Census Report showed a total population of 2,409,509 souls, which with an area of 2,656 square miles, gives a density of population of 907 souls to every square mile. Of the entire population of the district, 81 per cent. are dependent upon agriculture. The total number of agriculturists was returned in 1901 as 1,952,254 and the total net cropped area amounting to 1,341,600 acres, the average number of agricultural persons to every square mile of the cropped area is 931. This shows a higher density than that of any other district of Bihar and noticeably higher than that of Chota Nagpur. The average size

of village, holding and plot is very much smaller in Saran than in any other district visited by me; but the cultivators as a body may be said to be fairly well off. The population is said to have practically reached the utmost limits which the district can support, but the relief to the situation is in the steady emigration that is being recorded annually, which puts Saran in this respect above all the other North Bihar districts. The proportion of emigrants to natives is as high as one to ten. Labour is abundant, and this with the energetic character of the people account for its high cultivation and its comparatively advanced artificial irrigation.

Famine, scarcity, drought, &c.—The district has suffered from all the great famines which have visited Bihar, but it has suffered to a much less extent than the other three districts of North Bihar. This is due to the fact, that rice is not an important crop here. The people therefore are not altogether at the mercy of a year of insufficient rain. The failure of the rice crop due to this cause can always be made up for by a good *rabi* harvest as is the case in the Eastern districts of the United Provinces. The variety of its crops and its partial independence of the winter rice harvest have given it comparative immunity from famine.

Cultivation.—The net cropped area, which amounts to 1,341,600 acres, forms 78·39 per cent. of the total area of the district. Of this net cropped area, only 33·39 per cent., is under rice. This is the lowest rice area to be found in Bihar. Among individual food crops, rice, no doubt, is the most important, but even in this respect as compared with Muzaffarpur and Champaran, it holds a secondary place. On the other hand, *rabi* crops occupy a most prominent place covering an area which is 74 per cent. of the net cropped area. This area is much higher than that of all other Bihar districts, Monghyr excepted. The South Bihar Districts have about half their cultivated area under *rabi*. The percentage of *bhadri* crops, exclusive of rice, with reference to the net cropped area is 36·14. As a sugarcane growing district, Saran stands first in Bihar and Chota Nagpur, the crop occupying 3·76 of the cropped area, but it does not reach the standard of sugarcane cultivation to be found in Ghazipur, Ballia and Gorakhpur in the United Provinces. Shahabad comes next in this Province. In respect of poppy cultivation, Saran comes next to Champaran.

The above statistics show a marked predominance in the district of crops which require well irrigation, and while the system of irrigation is more advanced here than in many other parts of Bihar or Chota Nagpur, the necessity of further development in this direction is evident.

Irrigation (a)—Statistics.—Although complete statistics of irrigation are not available for this Province, it is certain that in the matter of irrigation from wells, Saran stands ahead of all the other Bengal districts. Total figures for the district with regard to this kind of irrigation in the case of Saran, Champaran, Muzaffarpur and Darbhanga are given in the Final Settlement Reports. It will be useful to reproduce and discuss them in the present monograph. The table below gives thana by thana, the sources of irrigation, and their percentages with reference to the net cropped and irrigated areas at the time of the Settlement, and they very fairly represent present irrigation conditions:—

DIVISION.	Thana.	Net cropped area.	Total irrigated area.	Per- centage to net cropped area.	SOURCES OF IRRIGATION.										
					Irrigated from wells.	Per- centage to cropped area.	Per- centage to total irrigated area.	Irrigated from private canals.	Per- centage to cropped area.	Per- centage to total irrigated area.	Irrigated from tanks.	Per- centage to cropped area.	Per- centage to total irrigated area.	Irrigated from other sources.	Per- centage to net cropped area.
		Acre.	Acre.		Acre.			Acre.			Acre.			Acre.	
...	Mirganj ...	231,034	53,555	23·31	31,013	14·72	63·15	2,595	1·29	4·82	14,410	6·24	28·75	2,637	1·23
...	Gopalganj ...	155,332	10,024	6·45	8,128	5·23	81·06	249	0·16	2·48	1,020	0·67	10·17	620	0·39
...	Siwan ...	173,223	21,008	12·33	15,948	9·10	73·81	112	0·06	0·51	4,158	2·37	13·24	1,390	0·79
...	Basatpur ...	125,633	12,721	10·13	10,735	8·56	84·38	280	0·22	2·20	897	0·71	9·05	809	0·71
...	Darauli ...	123,572	40,545	33·38	27,967	23·82	68·95	507	0·41	1·27	9,207	7·51	23·71	2,864	2·34
...	Manjhi ...	69,8·6	19,261	27·59	14,589	20·91	75·79	258	0·37	1·34	2,340	3·35	12·14	2,064	2·96
...	Chapra ...	157,060	24,620	15·67	18,136	11·55	73·67	795	0·50	3·23	3,199	2·03	12·99	2,480	1·55
...	Mashrakh ...	80,180	3,444	4·29	2,669	3·33	71·49	65	0·08	1·93	314	0·39	9·12	390	0·49
...	Para ...	130,037	6,895	5·32	5,899	4·54	5·55	60	0·05	0·87	353	0·27	5·12	633	0·45
...	Sonpur ...	37,233	1,451	3·89	1,370	3·68	91·43	6	0·02	0·41	57	0·16	3·92	18	0·05
	Total ...	1,284,010	194,424	15·14	139,462	10·86	71·73	4,927	0·38	2·63	35,955	2·80	19·49	14,080	1·09

An extensive canal system was initiated in the year 1881, but it did not prove of much value and was finally abandoned. The total irrigated area bears a proportion of 15·14 per cent., to the net cropped area. Of the net cropped area, 10·86 per cent. is irrigated from wells, and only 4·28 per cent. from all other sources, so that wells are the chief source of irrigation in the district. In fact, as much as 71·7 per cent. of the total irrigated area receives its water from wells. The crops thus benefited are mainly *rabi* crops and such special crops as sugarcane, opium, tobacco and garden vegetable crops. *Cheena* is also irrigated as a general rule.

It will be instructive to compare these figures with corresponding figures of the Eastern districts of the United Provinces. They are all shown in the subjoined statement—

PROVINCE.	District.	Year for which figures are quoted.	Net cropped area.	Irrigated from wells.	Percentage to net cropped area.	Irrigated from other sources.	Percentage to net cropped area.	Total area irrigated	Percentage to net cropped area.
United Provinces	Ghazipur	1904-05	619,361	140,392	22·66	63,303	10·22	203,695	32·88
	Ballia	1904-05	552,918	136,290	22·83	43,425	7·8	179,715	32·54
	Gorakhpur	1904-05	2,062,080	225,044	10·91	2,4,947	14·29	519,991	25·20
Behar	Saran	1901	1,281,010	132,462	10·86	54,962	4·27	187,424	15·14

The percentages given above clearly show, that as regards irrigation, Saran is far behind the Eastern districts of the United Provinces. Comparing Saran with Ghazipur and Ballia, where physical, agricultural and economic conditions are similar, the proportion of its well irrigated area to the net cropped area (10·86 per cent.) is only half of the corresponding proportion in Ghazipur (22·66 per cent.), and Ballia (22·83 per cent.). Saran offers as suitable conditions for well-irrigation as Ghazipur and Ballia, and there is no reason why it should be so far behind hand in this respect.

(b) *Suggestions for improvement.*—The configuration of the country, the nature of the soil and subsoil, the water-level are such that the district admits of well irrigation in all the thanas. The cultivators themselves are energetic and enterprising and know how to construct wells, and to utilize the water for their crops, and all that they need is encouragement and help of some kind.

Considering now the figures of Saran itself in reference to the tracts under the control of wells, it will be seen from the district statement given in a previous paragraph that Darauli, Manjhi, Mirganj and Chapra thanas are most advanced; Gopalganj, Mashrak, Parsa and Sonpur have very small proportions irrigated, while Saran and Basantpur show a fair amount of irrigation. Taking the district as a whole, there is still great scope for irrigation in almost every thana. Permanent and temporary wells may well be dug all over the district. It is reported that a narrow strip of land in the west along the Ganges from Dighwara right up to Manjhi is well suited for the sinking of *kachcha* wells, but in my opinion, the entire district opens out a field for such wells. As for permanent wells, my own experience of the district is that Darauli and Mirganj are at present fairly well supplied. In the latter thana, much has been done by the Hathwa Raj, and the work of construction is still going on. The Raj supplies all the necessary funds and is content to recoup itself by the improved condition of its tenants. Hathwa is the largest estate in the district under the Court of Wards. It comprises an area of 400,000 acres and extends over the greater portion of the Gopalganj Subdivision. In the final Settlement Report of the district, it is stated that during 28 years 1,226 masonry wells were constructed at the expense of the Raj. Figures kindly supplied by the Collector of Saran show that the estate has incurred the following expenditure for the construction of irrigation-wells during the last three years—

Year.	Number of wells.	Rs.
1903-04	329	20,225
1904-05	229	13,475
1905-06	150	7,425

The programme for the next five years provides for the construction of some 350 wells per annum and it is proposed to double the existing number

of wells in 10 years. The only suggestion that I need make here is that the sinking of wells be further pushed on by the Raj in the Gopalganj thana. Government need not make advances directly for this tract, as whatever is required for the development of irrigation here would be undertaken by the Raj. I have not much personal experience of Masrak, Parsa, and Basantpur, but no good reasons have been adduced against well construction in these thanas. Of the Manjhi, Chapra and Siwan thanas, I have better experience and I would strongly recommend that the sinking of permanent wells be extended here on a large scale. In this opinion, I am supported by the Collector. The construction of such wells would undoubtedly lead to the extension of sugarcane, for which crop the soil is well suited, and for which there is now a growing demand in the district. It would also lead to the extension of the *rabi* area and the increase of the *rabi* harvest. If any encouragement be necessary for such extension, it will be found in the opinion given by Mr. E. B. Chapman, I.C.S., in his Famine Report of 1896-97 which runs thus: "Nothing was more striking than the complete cessation of distress in the Mirganj and Darauli thanas after the excellent *rabi* harvest which was secured, I believe, by well-irrigation". The opinion expressed here is corroborated by the experience in the Eastern districts of the United Provinces during the same famine, when well irrigation with an excellent *rabi* harvest following in its train, undoubtedly saved the people from acute distress. Sonpur hardly requires any irrigation.

There are 42 Government estates in the district, covering an area of about 15,000 acres. Most of these lie in the Sadr and Siwan subdivisions, and a large proportion consist of *diara* lands, where irrigation is not necessary. But the Collector thinks that well construction can be developed with advantage to some extent in Umdha, Jagadispore and Company Bagh estates in the Sadr subdivision and in Bangra in the Siwan subdivision. As regards Wards' estates, the work done by the Hathwa Raj has been already noticed. The other Ward estates are small, and some irrigation-wells have already been constructed in them. The Collector is of opinion that there is still room for development of this work in all the estates, but it depends upon the money that can be spared for the purpose.

The cost of construction of *kachcha* wells in Saran is nominal, as in the United Provinces and in other parts of Bengal. It varies from Rs. 2 to Rs. 4. As the cost of *pakka* wells, I have been given figures varying from Rs. 100 to Rs. 300. Water in Saran may be found at a level of from 10 to 30 feet. Fifteen feet may be accepted as a fair average for low lands and 25 feet for uplands. The common lift in the country is the lever bucket. *Mots* are also to be seen. Their scarcity may perhaps be due to the shallowness of the average well. I would certainly recommend sinking deeper than is usually done in the case of permanent wells *i.e.*, until a good *tawa* or clay platform is reached, for a good and continuous supply of subterranean water. This remark would apply generally to all districts, where the bucket lever predominates and the *mot* is scarcely to be seen. Another probable cause of the more general use of the lever may be that in Saran, more than in any other district in Bihar, the *raiyat's* individual plots are small, and they can therefore be more economically watered from the lever lift.

MUZAFFARPUR.

General description.—Muzaffarpur forms part of the great alluvial tract of Bihar. Like Darbhanga, its rivers mark off three distinct physical divisions.

The southern portion lies south of the little Gandak. It is the most fertile portion of the district, consisting of high lands suitable for a variety of crops. The second portion is the *doab* between the little Gandak and the Baghmati. It is the lowest lying portion of the district, and grows rice chiefly, though *bhadori* and *rabi* crops may also be found on it. The third tract is that which lies to the north of the Baghmati and extends up to the Nepal hills. It is for the most part low lying with rice as the staple crop. Further north, the land gets more and more marshy. The soils are exactly similar to those found in other alluvial North Bihar districts, consisting of the usual admixture of clay and sand in different proportions.

Rainfall.—The normal rainfall of the district is 45·88 inches. A great amount of moisture is however received from the rain which falls in and comes

down from Champaran and Nepal. The variations in the fall during the last ten years will be seen in the table below:—

Year.		Actual fall in inches.	Year.		Actual fall in inches.
1896	...	32.79	1901	...	32.19
1897	...	45.13	1902	...	45.02
1898	...	56.35	1903	...	33.53
1899	...	66.85	1904	...	47.40
1900	...	39.44	1905	...	60.54

Population, material condition, emigration.—In 1901, the population of the district stood at 2,754,790 souls, and the area was returned as 3,004 square miles so that there were 917 persons per square mile, showing a greater pressure of population over the whole district than any other district of Bihar or Chota Nagpur. The effect of this pressure has been that the value of land has gone up a great deal, and every day the competition for land is getting keener and keener. Muzaffarpur takes however a place second to Saran in the density of its agricultural population on the cultivated area, there being 864 persons to the square mile, against 931 in Saran. Emigration is common, but labour is not scarce in the district, and the condition of the people, if not as good as in Saran, is far ahead of their condition in Champaran and Darbhanga. There is in this district the same dependence upon the rainfall and the rice crop as in Darbhanga and Champaran, and there is, therefore, necessity for vigorous development of the cultivation of a variety of crops, and with it the extension of that system of irrigation which may effect this end.

Famine, scarcity, drought, &c.—Of the four districts of North Bihar, Saran has the smallest area under rice and is least susceptible to famine. Muzaffarpur comes next, and does not show signs of distress as quickly as Champaran and Darbhanga. In common with other Bihar districts, it has been visited by all the great famines, but, as in Saran, the people here have shown great powers of resistance throughout all these periods of distress.

Cultivation.—The net cropped area (1,552,900 acres) is nominally higher than that of Saran and Darbhanga, and distinctly higher than that of Champaran, being 79.94 per cent. of the total area of the district (1,942,400 acres). Of this area, 50 per cent. is under rice, 70 per cent. under *rabi* crops, while the *bhadoi* area without rice is 27½ per cent. In respect of the *rabi* area, it takes the second place in North Bihar, which emphasizes the importance of good and sufficient irrigation from wells. Whether it receives this irrigation or not will be discussed later on. The sugarcane area is less than in the other North Bihar districts, and this may be set down as partially due to the want of wells. There is nothing to show that the soil is unsuited to the crop.

Irrigation—(a) Statistics.—The table below, compiled from figures given in the Final Settlement Report of the district, gives details of the sources and extent of irrigation:—

SUBDIVISION.	Thana.	Net cropped area.	Total irrigated area.	Percen- tage to net cropped area.	SOURCES OF IRRIGATION.										Irrigated from other sources.	Percentage to net crop- ped area.	Percentage to total irri- gated area.
					Irrigated from wells.	Percentage to net crop- ped area.	Percentage to total irri- gated area.	Irrigated from private canals.	Percentage to net crop- ped area.	Percentage to total irri- gated area.	Irrigated from tanks and <i>dhars</i> .	Percentage to net crop- ped area.	Percentage to total irri- gated area.				
		Acres.	Acres.		Acres.			Acres.			Acres.			Acres.			
Sitamarhi ...	Sinhar	107,828	785	0.73	54	0.05	6.88	...	...	...	328	0.30	41.78	403	0.37	51.34
	Sitamarhi	198,138	719	0.36	107	0.05	14.88	14	0.01	1.95	250	0.13	34.77	348	0.18	48.40	
	Papri	130,106	3,923	3.01	5	0.004	0.13	115	0.09	2.93	763	0.58	19.42	3,041	2.34	77.52	
	Belsund	113,124	738	0.65	8	0.007	1.08	29	0.02	3.93	268	0.24	36.31	433	0.38	58.67	
Sadar ...	Katra	120,416	273	0.23	17	0.01	6.22	12	0.01	4.39	71	0.06	26.01	173	0.14	63.37	
	Muzaffarpur	298,833	6,313	2.11	3,897	1.30	61.57	842	0.28	13.34	798	0.27	12.64	786	0.26	12.45	
	Paru	207,664	9	0.004	7	0.003	77.78	...	...	...	...	...	...	2	0.001	22.22
Hajipur ...	Lalganj	85,759	550	0.66	540	0.64	98.18	...	...	...	3	0.003	0.54	7	0.01	14.54
	Hajipur	130,254	11,212	10.01	9,807	8.05	87.47	...	...	...	728	0.76	6.49	977	1.19	6.04
	Manua	165,149	5,306	3.21	4,391	2.66	82.75	...	...	...	474	0.29	8.93	441	0.26	8.31
	Total ...	1,555,291	29,828	1.92	18,823	1.21	63.14	1,012	0.06	3.39	3,082	0.24	12.34	6,311	0.40	21.15	

The extent of irrigation is small. Against Saran, which shows 15·14 per cent. as the percentage of the net cropped area irrigated, only 1·92 per cent. of the same area shows irrigation in Muzaffarpur. The total irrigated area is even less than that of Darbhanga, where it is 6·4 per cent. of the net cropped area. The higher percentage in the latter district is accounted for by the larger irrigation it receives from tanks, *ahars* and other sources.

Well irrigation in Muzaffarpur, although slightly above the standard of Champaran and Darbhanga, is much below that of Saran. The percentages of well irrigated areas in these four districts are as follow :—

DISTRICT.			Percentage on the net cropped area.	Percentage on the total irrigated area.
Saran	...	...	10·86	71·73
Champaran	...	...	0·10	5·07
Muzaffarpur	...	...	1·21	63·14
Darbhangā	...	...	0·39	6 09

The figures rather tend to show that wherever irrigation is practised in the district, the well system is now more popular than other methods, covering as it does 63 per cent. of the total irrigated area. It is therefore very difficult to understand why the practice is not more widespread. To the north of the Baghmāti, the country is low and grows paddy for the most part. The central *doab* also grows a great deal of rice. In these tracts, irrigation from wells is not needed. Excluding them, I am quite of opinion, that the uplands to the south of the Gandak which are suitable for growing all kinds of crops require more attention in the matter of careful cultivation than is at present given to them.

(b) *Objections against irrigation.*—It is admitted on all hands, and in fact statistics, so far as they are available, clearly demonstrate the benefit derived from well irrigation in increasing the outturn, and the objection, therefore, raised in certain quarters that in Muzaffarpur, Darbhanga and Champaran, the soils when once irrigated require always to be irrigated seems to me to present no obstacle whatever. When once wells are constructed, where arises the difficulty of irrigating every year? I quite agree that if irrigation be once begun, it should be continued. In a watered field, there is no doubt that soil constituents are brought into a state of greater activity than in an unirrigated field, and thus plant food is made available in a larger quantity. The food thus made available is absorbed by the growing crop, and the land therefore gets more exhausted than the land to which no water stimulus has been given. A second explanation of the deterioration in soils, experienced by the discontinuation of irrigation may be as follows :—The micro-organisms which help chemical action in the soil get habituated to water, and without it they are not able to exercise their functions, and thus the proper food supply is withheld from plants. They are said to die off sometimes themselves when not properly fed with water. Whatever be the correct theory of deterioration, it is quite true that when once irrigation has been given, if it is not given in succeeding years it will be found that the soil has become so weakened that it will not produce as much plant food, as the soil which has not been irrigated. This would apply specially to well water, by which a greater stimulus is believed to be given to the soil than by other kinds of water. What is the objection to the stimulus being given regularly? It is admitted that watering from wells leads to the production of more valuable crops than can be raised on unirrigated lands. If this be the case, it ought to be sufficient inducement to accepting it as a distinct factor for good in the cultivation of the *raiya*'s crop. It must be granted that it is necessary to supplement irrigation with adequate manuring. Every good cultivator knows this. Manuring is as necessary in the case of canal or other systems of irrigation, so that this difficulty does not apply particularly to well-irrigation, but has to be confronted in all systems of irrigation. Economic and not soil conditions therefore appear to me to be the obstacle against well-irrigation. Expenditure, chiefly initial, has to be overcome. Then, again, the

conservatism of the *raiyat* has to be got over. Where he has not hitherto taken water from wells for his crops, there will be some slight difficulty at the outset to induce him to do so, but the difficulty is not insurmountable. I have come across many *raiyats* in different parts of North Bihar who are willing to make the experiment, if they receive some sort of assistance.

Again in Muzaffarpur, Champaran and Darbhanga, it is often stated that the soil is so retentive of moisture that irrigation is not necessary. This can be only partially true. It is difficult to understand that the rainfall of the district gives it in all parts the maximum of moisture that it requires for the production of good and valuable crops. Within the very areas that are said to need no artificial watering on account of the sufficiency of moisture, I have found large tracts with withering *rabi* crops, a result which the *raiyats* themselves admitted to me is due to the want of water. Then again, it is stated that well-irrigation leads to the formation of a crust below the surface, which impairs the fertility of the land if it is not continuously irrigated. On this point, I am unable to give any decided opinion. The formation of a crust is possible if there is a tenacious layer of soil immediately below the lighter layer. The soluble salts of the surface soil, as they are washed down by well water may be deposited when they reach this layer and thus form a crust injurious to the roots of crops. Rain water on account of the greater volume and of the greater velocity with which it descends into the soil would not produce as readily the same effect. It would take the soluble salts down to great depths, far away from the roots and some of them may not come up to the surface again, so injury from a crust formation would be more remote in such a case. Personally, I am very sceptical about the crust theory. If it is injurious to crops, tillage should suffice to break up the crust. For myself, I may add that I found no crust below the surface any where during my tours, but at the same time, I would say that it is quite possible for a crust to form in untilled lands. Observations taken in America have shown that the soluble salts ordinarily move up and down within the upper four or five feet of the soil and subsoil following the movement of the moisture, descending in the rainy season to the limit of the annual moistening as a maximum, and then reascending or not by capillary action, as surface evaporation may demand. Thus it may result that at the end of the dry season, in untilled irrigated land, practically the entire mass of salts would be found within six or eight inches of the surface. *I consider that the matter is well worthy of investigation, and would suggest that experiments in connection with it be under taken in North Bihar by the Agricultural Department.* It would be well to ascertain what this crust is, if it is formed at all, and how it is formed, and whether it really injures the roots of the plants or not.

(c) *Suggestions for improvement.*—The best irrigated tract by far in the district is Hajipur. It takes up 8·86 of the net cropped area, which is practically altogether watered from wells, and in this respect it is not far behind Saran. The result of this artificial irrigation is that Hajipur is the most fertile tract of Muzaffarpur and unlike the rest of the district, it is shown as immune from famine. In a year of deficient rainfall, it has not been known to experience acute distress, and its material prosperity is much above that of the rest of the district. This is surely an argument in favour of the extension of well irrigation throughout the district. The Hajipur subdivision may well be made the beginning and centre of work in Muzaffarpur. From here, the work may spread. The Collector advises, that well sinking should be started mainly in the portion which would be practically south of a line drawn from Lalganj to Tajpore (in the Darbhanga district.) This would comprise the Lalganj, Mahua and Hajipur thanas, inclusive of Sarai. In Lalganj, the present percentage of well-irrigation is only '64 per cent. There is practically no other form of irrigation here, as the percentage from all other sources is '02. Lalganj almost adjoins Hajipur, and it is inconceivable that there exist soil or climatic conditions here which prevent it attaining the 8 per cent. of Hajipur. I interviewed a very large number of cultivators at Lalganj who were of opinion that well-irrigation, far from injuring their soil, would benefit it much. They were willing to take advances for wells at a moderate rate of interest, and as a test case put to them, I had in the course of a morning no less than 25 petitions submitted to me for advances, which I

reminded them would be given with all the restrictions that accompany *takavi* advances for other kinds of improvements. What they desired was a slightly lower rate of interest, a receipt of the money at an earlier period of the year, to give them time for construction, and the payment to them of the money without having to proceed to the Collectorate, which involved many hardships. The matter of *takavi* advances will be dealt with further on. I have alluded to the subject here simply to show that well-irrigation is quite possible in Lalganj. I do not lay very great stress on the interview, as the real test would be at the time of realization, when the money with interest was wanted back. Help, encouragement and education are undoubtedly necessary for the development of well-irrigation in the country.

The difficulty to be overcome is the plea that is set up by cultivators in all unirrigated tracts, that it is not our *rawaj* (practice) to sink wells for our crops. We have never used well-water for this purpose, and we don't care to bother ourselves much about doing so now. We may no doubt get better crops, if we have wells for them in our midst, but we are quite content with what we get at present. The novelty of the idea, the expense and the extra labour involved, are the *raiya*'s stumbling block.

The other tracts in the district, in which wells may be sunk may now be considered. I would certainly extend the operations further north and include the thana of Muzaffarpur. The physical aspects here are similar to those of the more southern thanas. It comprises, with the latter thanas, the upland tract lying to the south of the little Gandak, which is suitable for the growing of all kinds of crops. The percentage of well irrigation here is only lower than that of the Hajipur and Mahua thanas, and the development of well irrigation here as well as in the latter two thanas would no doubt lead to the improvement of the *rabi* harvest. It should also stimulate the cultivation of sugarcane which occupies only 62 per cent. of the net cropped area, which is much less than the sugarcane area in any other district of Bihar. Paru thana, which is also south of the Gandak on a line with Muzaffarpur to the west, has practically no irrigation whatever. It is said to have a soil which resents the application of water by artificial means. Scientifically, I am unable to support such an opinion, but it would be most instructive to sink a few wells tentatively. Another argument in favour of well sinking in general, south of the Gandak, is that, if we consider well irrigation in reference to the total irrigated areas, we find that in all the thanas the percentage is over 75. This shows that this method of irrigation is not altogether unpopular in South Muzaffarpur. There is, at the same time, as I have already attempted to point out, a crying need for its extension on a large scale. If the above work be undertaken, much will have been done for Muzaffarpur. I would not recommend the sinking of wells for the present, either in the *doab* comprising thana Katreh or in the Sitamarhi subdivision to the north, for wells must first be sunk where they are most needed. The figures showing percentages from "other sources of irrigation" are also very low in the northern portion of the district, Pupri being the worst in this respect. The low figures show that the natural irrigational resources of the country are not taken advantage of by an unenterprising people, who are content with what nature has given them. There can be no doubt however, that there is still scope in the north for the damming up of streams and the construction of *ahars*.

As regards the methods of raising water, Muzaffarpur has the same kinds of lifts as are in use in Saran, the *dhenkal* lever being more common than the *môt*. Water is found ordinarily at a higher level than in Saran. In low lands, the level varies from 6 to 10 feet, and in uplands, it varies from 15 to 25 feet.

CHAMPARAN.

General description.—The general aspect of the district is very similar to the other districts of North Bihar. The southern portion is level and cultivated, while the northern portion near the hills is sparsely inhabited, and cultivated only to a small extent. The chief river is the Gandak, from the floods of which the district is protected by an embankment. A second river, viz., the Little Gandak, passes diagonally through the district from north-west to south-east, dividing it into two distinct agricultural portions, viz., the north-east

portion, chiefly comprising low paddy lands, and the south-west portion, consisting of higher lands suitable for the cultivation of *rabi* crops. The north-east tract gradually becomes marshy as it reaches the Terai. In the north, the soil is mainly clay (*bangar*); it is low-lying and is suitable for the cultivation of rice. The uplands (*bhat*), consist of the usual loams, sandy loams and sandy soils found in all uplands. They receive all the silt deposits brought down by floods, and are very good for *rabi* and vegetable crops.

Rainfall.—The normal fall of the district, as shown in recent reports, is 54.10 inches, which is heavier than that of any other district of Bihar or Chota Nagpur, but the rainfall is very unequal in its distribution. The character of the greater portion of the soil being such that it is retentive of moisture, the cultivators of Champaran depend solely on the rainfall and are unwilling to take to artificial means of irrigation. The actual falls that have been received for the last ten years are as follows:—

Year.	Actual fall in inches.	Year.	Actual fall in inches.
1896	... 28.35	1901	... 46.88
1897	... 55.84	1902	... 57.22
1898	... 59.79	1903	... 63.84
1899	... 69.88	1904	... 53.09
1900	... 48.79	1905	... 65.22

The north of the district, like the north of Gorakhpur, is very unhealthy. The southern portion is better, but on account of the heavier rainfall of the district, it is on the whole much damper than the rest of Bihar.

Population, material condition, emigration.—The area of the district is 3,531 square miles, and the density of population, according to the Census of 1901, 507 to the square mile—the lowest in North Bihar. The agricultural population, which numbers 1,437,464 persons, is 80 per cent. of the total population. Spread over a net cropped area of 1,200 square miles, this gives an average of 671 agricultural persons per square mile of area cropped, which is lower than in the rest of North Bihar. The pressure is more intense however than that of South Bihar, Patna excepted. The population being sparse, there is much land still available for cultivation. Holdings and plots are large. All these circumstances point to the desirability of doing what can be done to push on agricultural improvements in the district. In his Famine Report of Champaran, Mr. D. J. Macpherson, I.C.S., reported in 1897, that the "Economic condition of the people is far beyond the standard of adjoining districts." The Champaran cultivator, as already noticed, has the benefit of a good rainfall, and a general sufficiency of natural moisture in the soil. He therefore takes no trouble to improve his cultivation by artificial means of irrigation. It cannot be said, that this natural moisture is such that he does not need artificial irrigation. The very fact of the backward agricultural condition of the Champaran peasant points to his laziness and inefficiency brought on undoubtedly by the free gift given him by nature of a good rainfall. In the Terai portions of the district in the north, where the rainfall is very heavy and the country marshy and full of malaria, the physique of the *raiya* is very weak, and this physical disability may be an excuse for his poor cultivation. No such plea can justify the southern peasant in his neglect of careful cultivation. There is no emigration at all from the district, and it appears to me that there is much room for the immigration of more energetic and more skilful cultivators.

Famine, scarcity, drought, &c.—Champaran is altogether so dependent upon the rice crop that of North Bihar districts it is most susceptible to famine, in case of a bad monsoon resulting in a failure of the rice harvest. The question therefore of introducing a system of irrigation which will relieve this situation assumes great importance.

Cultivation.—The net area under cultivation (1,370,800 acres) is very low. It is less than that of the three other districts of North Bihar, being 60.56 per cent. of the total area (2,269,840 acres), against 78.39 per cent. in Saran, 79.94 per cent. in Muzaffarpur and 78.98 per cent. in Darbhanga. Rice, as in Darbhanga, is the principal crop. In the cultivation of *rabi* crops, the rest of North Bihar stands higher than Champaran. Sugarcane holds the same unimportant place as in the other North Bihar Districts, Saran excepted. In the matter of opium cultivation, Champaran heads the list. But it must be noted here, that

a great deal of the opium is irrigated from other sources than from wells. Statistics of the Opium Department show, that out of 26,000 opium *bighas* which are irrigated from all sources, only 6,000 *bighas* receive their watering from wells. In fact, like all other crops, opium here is cultivated with little or no care; and it consequently shows a very small outturn in the reports of the Department.

Irrigation—(a) *Statistics*.—Figures of irrigation as given in the Final Settlement Report show that it is hardly practised in Champaran. Throughout the net cropped area, only 1·92 per cent. of the land is irrigated; and as for irrigation from wells, it may be said to be altogether absent. The percentage is the lowest in North Bihar, viz., ·10. Darbhanga is almost as bad, as will be seen later; its well-irrigated area occupies only ·39 per cent. of the net cropped area.

Full details of irrigation are given in the following statement:—

DIVISION.	THANA.	Net cropped area.	Total irrigated area.	Percentage to net cropped area.	SOURCES OF IRRIGATION.										Percentage to net cropped area.	Percentage to total irrigated area.
					Irrigated from wells.	Percentage to net cropped area.	Percentage to total irrigated area.	Irrigated from private canals.	Percentage to net cropped area.	Percentage to total irrigated area.	Irrigated from tanks and ahars.	Percentage to net cropped area.	Percentage to total irrigated area.	Irrigated from other sources.	Percentage to net cropped area.	Percentage to total irrigated area.
		Acres.	Acres.		Acres.			Acres.			Acres.			Acres.		
tiah ...	Bagaha ...	198,823	7,002	3·52	13	00·06	0·18	1,230	0·62	17·57	71	0·04	1·01	5,388	2·71	76·95
	Shikarpur ...	244,781	11,204	4·58	80	0·03	0·71	4,237	1·73	3·81	1,186	0·48	10·58	5,413	2·21	48·31
	Bettiah ...	243,139	622	0·26	664	0·23	90·67	157	0·06	25·24	137	0·06	22·93	381	0·16	61·25
	Adapur ...	122,198	4,976	4·07	519	0·42	10·45	324	0·27	6·51	2,475	2·03	40·74	1,503	1·23	30·08
	Dhaka ...	177,846	2,942	1·66	153	0·09	5·20	238	0·15	8·77	1,402	0·79	47·06	1,116	0·63	37·93
	Motihari ...	131,337	1,014	0·79	72	0·05	6·80	62	0·05	5·94	443	0·34	42·43	454	0·35	43·48
	Gobindganj ...	127,363	37	0·03	9	00·07	24·32	...	...	...	...	...	...	...	...	...
	Kesaria ...	183,468	...	...	...	...	100	...	...	...	...	...	...	...	...	...
	Madhuban ...	63,118	2	00·03	2	00·03	...	...	...	...	...	...	...	...	...	...
	Total ...	1,447,068	27,829	1·92	1,412	0·10	5·07	6,268	0·43	22·52	5,714	0·33	20·53	14,312	0·99	51·09

(b) *Objections against irrigation*.—It does not appear to be necessary to discuss these figures at length. The only conclusion deducible from them is that irrigation is not popular in Champaran. The same prejudice against it is found here as in Muzaffarpur, but more emphasized. The rainfall is heavier than that in all other districts of Bihar, the soil is fertile, and in normal years crops are raised with little or no labour. The *raiya*s thus make no effort at improvement. They are quite content with their rice crop, for which they depend totally upon the monsoon, and are blind to the gravity of a failure of this crop.

(c) *Suggestions for improvement*.—The only recommendation, that I can offer in connection with well irrigation in Champaran is that sustained efforts be made for its extension in those tracts in which well irrigation is already known. I would particularize the thanas of Adapur, Dhaka, Gobindganj, Madhuban and Motihari, where wells exist for the opium crop. All these tracts are more or less suitable for all kinds of *rabi* crops, the quantity and quality of which sadly require improvement, which can only be effected by systematic watering from wells. The largest Wards' estate in the district is Bettiah, but well irrigation in this estate is not looked upon with favour. The pressure on the soil is light, and land is still available for cultivation. I would therefore suggest for this district especially, and generally for all backward districts similarly situated, that cultivators be induced to come and settle in them from more advanced districts, where high cultivation is conducted with skilful irrigation. It should not generally be difficult to obtain land for their colonization. I think, however, that difficulty would arise in getting men to come and settle down in lands which are less productive than their own. Government alone can surmount this difficulty by offering the would-be settlers favourable terms in the occupation of their new lands. The improvements effected by them are bound to leave their impress upon the natives of the districts to which they may immigrate.

From the measurements taken by me of the depth of many wells in the district, I found that the average depth at which water is to be found in

Champanan varies from 15 to 25 feet. The depth of water in the wells towards the third week of March varied from 6 to 10 feet. The common lift of the district is the lever and bucket. In these respects, Champaran more or less resembles the other North Bihar districts.

DARBHANGA.

General description.—Darbhanga is altogether an alluvial plain. There are three main river systems which divide the country into three distinct physical tracts. The first tract comprising the Sadr and Madhubani divisions in the north consists mostly of low lying rice lands, though in the west of Madhubani uplands are found suitable for *rabi* crops. The second portion is the *doab*, which is also low lying and grows rice, and to some extent *rabi* on lands receiving silt deposits. The third portion, Samastipur, occupies the south of the district. It consists of uplands which grow excellent *rabi* crops. The soils are similar to those found in Muzaffarpur.

Rainfall.—The normal rainfall of the district is 49·73 inches. It is lower than that of Champaran, but higher than that of Saran and Muzaffarpur, and is sufficient for the agricultural operations of the district. The annual fall, however, as in the other districts of Bihar, shows great variation from the normal, as will be seen from the following table :—

Year.		Actual fall in inches.	Year.		Actual fall in inches.
1896	...	37·98	1901	...	36·50
1897	...	45·66	1902	...	56·24
1898	...	55·54	1903	...	36·96
1899	...	69·86	1904	...	49·04
1900	...	44·61	1905	...	70·54

Irrigation becomes necessary to contend against this uncertainty.

Population, material condition, emigration.—The total area of the district in 1901 was 3,335 square miles, and the density of the population 873 to the square mile. The agricultural population at the time of the Census was found to amount to 2,269,835 persons, or 78 per cent. of the total population. This, spread over 2,644 square miles of cultivated land, gives 858 persons per square mile. In the face of these figures, the question of labour as regards agriculture may be set at rest. There is also very little emigration from the district. Taking good years with bad, it is reported that Darbhanga cultivators enjoy a moderate degree of comfort; but, like Champaran, it must be admitted that the economic condition of this district is not of a very high standard. The Darbhanga peasant has not yet attained the efficiency of the Saran or even of the Muzaffarpur cultivator, and the reason is not far to seek. Depending on the rice crop, which covers the greater part of the cropped area, his conservatism and laziness prevents him from taking to more careful cultivation. Like his Champaran neighbour, he requires to be taught the benefits of artificial irrigation and of the growth of a variety of crops, which would relieve him of the fear of distress due to a failure of the rice harvest.

Famine, scarcity, drought, &c.—The causes of famine in Darbhanga are the same as in other Bihar districts. The failure of the rice crop always causes distress. This has been illustrated during all the famines that have visited the district. But the peasantry are said to have a reserve on which to fall back in years of scarcity, and they are not compelled to live a mere hand-to-mouth existence.

Cultivation.—Darbhanga is not lower than the other districts of North Bihar in respect of its net cropped area (1,692,400 acres). This area amounts to 78·98 per cent. of the total area, against 78·39 per cent. in Saran, 79·94 per cent. in Muzaffarpur, and only 68·46 per cent. in Champaran. In its rice area (58·98 per cent. of the net cropped area) it stands above all these districts. This crop is found chiefly in the Sadr and Madhubani subdivisions. The *rabi* area (53·07 per cent. of the net cropped area) is slightly above that of Champaran, and less than that of Muzaffarpur and Saran. There are small areas under sugarcane and opium.

Irrigation—(a) Statistics.—In the matter of irrigation in general, Darbhanga is more advanced than Champaran and Muzaffarpur, but there is a great

falling off when compared with Saran. The irrigated area occupies 6·46 per cent. of the net cropped area, but in this area wells take a very insignificant place, the greater portion of its water for cultivation being supplied from tanks, *ahars* and other similar sources. The well irrigated area is only ·39 per cent. of the net cropped area, which is noticeably low, and 6·09 per cent. of the total irrigated area, which is lower than that of Muzaffarpur; while the area irrigated from tanks, etc., is 5·88 per cent. of the net cropped area, and over 90 per cent. of the total irrigated area.

The relative importance of the different sources of irrigation, thana by thana, will be seen from the figures in the following statement:—

DIVISION.	THANA.	Net cropped area.	Total irrigated area.	Per cent. to net cropped area.	SOURCE OF IRRIGATION.										Per cent. to net cropped area.	Per cent. to total irrigated area.
					Irrigated from wells.	Per cent. to net cropped area.	Per cent. to total irrigated area.	Irrigated from private canals.	Per cent. to net cropped area.	Per cent. to total irrigated area.	Irrigated from tanks and <i>ahars</i> .	Per cent. to net cropped area.	Per cent. to total irrigated area.	Irrigated from other sources.	Per cent. to net cropped area.	Per cent. to total irrigated area.
		Acres.	Acres.		Acres.			Acres.			Acres.			Acres.		
hubani ...	Benipatti ...	136,666	43,573	32·59	176	0·13	0·41	1,043	0·76	2·39	24,027	17·59	55·14	18,326	13·41	42·06
	Khajauli ...	166,998	19,141	11·46	361	0·22	1·89	706	0·42	3·69	8,049	4·82	42·05	10,025	6·10	52·37
	Phulparas ...	233,766	27,428	11·73	1·4	0·05	0·48	1,139	0·49	4·15	9,239	3·92	30·04	17,016	7·26	65·26
	Madhubani ...	145,927	7,919	5·43	28	0·02	0·35	255	0·17	3·22	4,649	3	58·71	2,987	2·05	37·72
	Darbhangha ...	51,166	1,062	0·46	22	0·01	2·07	9	0·004	0·85	145	0·07	13·65	886	0·42	83·43
astipur ...	Bahera ...	225,688	1,658	0·73	20	0·01	1·21	9	0·004	0·54	889	0·39	53·62	740	0·33	44·65
	Rusera ...	175,614	210	0·12	31	0·02	14·78	...	...	...	22	0·01	10·47	157	0·09	74·76
	Warisnagar ...	104,915	1,441	1·37	712	0·67	49·41	...	...	...	161	0·15	11·17	563	0·54	39·42
	Samastipur ...	157,902	3,031	2·49	3,099	1·96	78·83	...	...	...	346	0·22	8·80	436	0·31	12·36
	Dalsingh Sarai	132,401	3,029	2·29	2,063	1·57	68·76	...	...	...	366	0·27	12·08	580	0·44	9·15
	Total	1,092,443	109,391	6·46	6,666	0·39	6·09	3,161	0·19	2·89	46,893	2·77	42·86	52,671	3·11	48·14

The remarkable feature of the statement is the high percentage shown for the three thanas of Madhubani, the northern subdivision of the district. Here, as in the north of the submontane tract of Gorakhpur in the United Provinces, but in strong contrast to the northern subdivision of its sister district—Muzaffarpur, free advantage is taken of the numerous hills and streams that pass through the country for the irrigation of the winter rice crop. Very prominent in this area is the irrigation from *ahars* and *pains* from the Kamla. This irrigation was brought to the notice of the Irrigation Commissioners as having been the means of saving a large area under winter rice in the Darbhanga Raj during the dry monsoon season of 1901. Another feature of the statement worthy of notice is the prevalence of well irrigation in the southern subdivision of Samastipur as compared with the rest of the district. While in the Samastipur subdivision, wells account for 1·5 per cent. of the irrigation of its net cropped area and 70 per cent. of that of its total irrigated area, in the rest of the district they are found occupying only ·05 per cent. of the former area and ·76 per cent. of the latter area.

(b) *Suggestions for improvement.*—Now arises the question as to what can be done for the improvement of well irrigation in the district, which, taken as a whole, is very deficient. To begin with, the same arguments are put forward against well irrigation in Darbhanga as are urged in Muzaffarpur and Champaran. I am decidedly of opinion that there is room for the construction of wells in the district. In Samastipur wells exist, but their number requires to be increased. Although, as shown above, they cover about ·70 per cent. of the total irrigated area of the subdivision, the lands irrigated by them occupy only 1½ per cent. of the net cropped area of the subdivision, which consists of uplands quite capable of producing high class *rabi* crops with artificial irrigation and careful cultivation. The soil also is suited to the sinking of wells.

All circumstances considered, therefore, I would recommend that the sinking of permanent wells for the district be first commenced in this subdivision and that *kachcha* well irrigation be also encouraged here. The northern line of demarcation would probably be the Baghmati. In the *doab* to the north of this river, well irrigation is not so necessary, as the main portion consists of a

low lying rice area, but even here well irrigation may be encouraged in essentially *rabi* growing tracts. In the Madhubani subdivision, which is so well commanded by *ahars*, *pains* and tanks, I found many cultivators in favour of well irrigation, which they informed me would yield better *rabi* harvests than the modes of irrigation mentioned above. Mr. J. T. Whitty, I.C.S., the Subdivisional Officer of Madhubani, who takes a keen interest in the subject, informed me, after making enquiries, that he is of opinion that "there is undoubtedly room for irrigation in parts of the subdivision, though not perhaps over a wide area." I fully endorse this opinion, and agree with him, that well irrigation could be introduced and extended with benefit in the jurisdiction of the Madhubani and Khajauli police stations. As for the entire district, the Collector informs me that the Saraisa pargana is the tract where well sinking should be undertaken. In his opinion, wells are chiefly required in this tract. Saraisa is the largest pargana in the district occupying areas of 296 square miles and 178 square miles, respectively, in the Samastipur and Dalsing Sarai thanas of subdivision Samastipur.

The question of well construction may also be taken up in the eight Government estates in the district and in the Narhan Court of Wards' estate, the lands of which are scattered all over the district.

Measurements taken by me in the month of April showed a depth of water in *pakka* wells varying from 7 to 10 feet. The water level on the average was about 20 to 25 feet below ground level, but it varied a great deal. *Kachcha* wells, 12 feet deep, had about 4 feet of water in the same month.

MONGHYR.

General description.—Monghyr is divided into two distinct portions by the river Ganges, each of which presents altogether distinct physical conditions. The tract north of the Ganges is a low alluvial plain subject to inundation; but at the same time it is very fertile and thickly populated. The portion south of the Ganges is interspersed with hills.

Rainfall.—The normal rainfall of the district is 49.73 inches, but for the last 10 years, the fall has varied from 29½ inches to nearly 61 inches as will be seen from the following table.—

Year.		Actual fall in inches.	Year.		Actual fall in inches.
1896	...	42.02	1901	...	35.93
1897	...	50.89	1902	...	37.15
1898	...	54.24	1903	...	29.56
1899	...	60.86	1904	...	50.41
1900	...	47.70	1905	...	56.10

Population, material condition, emigration.—With a total area of 3,922 square miles, and a total population of 20,68,804 persons, the pressure on the soil is represented by 527 persons to every square mile of area. The agricultural population, which numbers 13,61,889 persons, shows a density of 837 persons on every square mile of the cultivated area (1627 square miles) and forms 65.8 per cent. of the total population. This percentage is lower than that of North Bihar. The condition of the Monghyr peasant is no worse than that of other neighbouring districts. It is reported to have improved very much of late years.

Famine, scarcity, drought, &c.—The district is not particularly liable to famine on account of drought, though it suffers frequently from distress due to floods. There is enough labour for efficient cultivation.

Cultivation.—The net cropped area compares unfavourably with the other districts of Bihar, occupying only 41.48 per cent. of the total area of the district. This is due to the fact, that excepting the alluvial area, a large portion of the district is covered with rocky hills. If this area be excluded, the percentage of total area under cultivation is about 80 per cent. The rice area of the district is 38½ per cent. of the net cropped area, which is lower than that of all the other Bihar districts, Saran excepted. In its cultivation, *rabi* crops take an important place occupying over 90 per cent. of the net cropped area. Artificial irrigation from wells consequently should form the main feature in the irrigation system of the district. Sugarcane is still an unimportant

crop, though with the nature of the soil available, its area could readily be extended, if well-irrigation were to become more general. Poppy cultivation is much more advanced in Monghyr than in any other part of the Bhagalpur division, and it receives its full share of water from wells.

Irrigation.—In the very low lying rice tracts, irrigation is not resorted to at all, but the rice on higher lands is always irrigated in all parts of the district, the water being supplied from *chars*. None of the other important crops are irrigated. In the higher lands of the south, where opium and sugarcane are grown, water for irrigation is taken from wells and *ahars*. Vegetables, including potatoes, are also watered from wells, but in the case of *rabi* crops generally, well irrigation is sadly neglected. The lifts used for well irrigation are the *mot* and *dhenkal*. The latter is the more common. The whole of the *rabi* area is practically left unirrigated. Papers obtained from the Settlement office show, that in the portion of the district which has been cadastrally surveyed, the total irrigated area amounts to only 2·58 per cent. of the net cropped area. It is believed that very little of this area even owes its irrigation to wells. There is, therefore, ample scope for extending this kind of irrigation. There is no urgent necessity for it in the North-Eastern tracts which are subject to inundation, and in which rice is the principal crop; but it can well be recommended for the rest of the district, where floods do not reach, and where the *rabi* crops suffer for want of moisture in the soil. There are many tracts also which are protected by embankments from floods. Well water would be of benefit here, for the lands are found to be generally dry. The water level in these parts varies from 25 to 50 feet and is therefore not out of reach and it is not unlikely that the *tawa* or clay platform would be found here at a depth of about 35 or 40 feet. Wells of this depth were found by me to contain 5 to 7½ feet of water in the beginning of May, so that there is no particular fear of their drying up. The particular tracts in which permanent wells may be dug as a beginning are noted below with remarks as to their necessity.

(1) *Thana Chakai*.—A good many wells have already been sunk by the Jamui Local Board, but they are for drinking purposes only. A pretty good area of land is still uncultivated, and the presence of wells might be the means of the introduction of a variety of crops.

(2) *Thana Sikandra*.—A good many wells for drinking purposes have already been sunk by the Jamui Local Board. The tracts which suffer in a year of drought are as follows:—(a)—Villages on both sides of the road from Sikandra to Arha, (b)—Villages on both sides of the road from Lakhisarai to Sikandra, (c)—Villages on both sides of the road from Sikandra to Seikhpura, (d)—Villages on both sides of the road from Sikandra to Jamui.

(3) *Thana Jamui*.—Wells for drinking purposes have already been sunk by the Jamui Local Board. The cultivated lands here mostly belong to the Maharaja of Gidhour and to the Raja of Khaira and partly to the Banail Raj. Hero well sinking should be an easy matter.

(4) *Thana Lakhisarai*.—Water is wanted by villages on both sides of the road between Lakhisarai and Jamui.

The approximate total area of all the tracts within which wells may be sunk may be taken roughly at about 500 square miles. Although the general water level, as given above, is shown as varying from 25 to 50 feet, there are extensive strips of land at the foot of the hills, which receive water from the hill streams and where water is to be found at a depth of 8 to 10 feet. Here, shallow *kachcha* wells are to be found being used for the irrigation chiefly of of vegetable crops.

Along the foot of these hills, the number of such wells may well be increased. They can also be sunk on the outskirts of the town of Monghyr.

The District Engineer has suggested to me that a few wells may be constructed in mouzahs which come under the jurisdiction of the Baktiarpur and Chiriya Bariarpur thanas, but these thanas may be left out of the scope of work at present as their position makes them unsuitable for the sinking of good wells. Much cannot be done in the matter of wells in Government Wards Estates in Monghyr, as I learn from the Collector that most of the lands of these estates lie in the *diaras*, subject to the fluvial action of rivers, where irrigation is not wanted. In Monghyr, it would not be necessary to make the deep wells *pakka* in all cases. It often happens that the substratum after a certain depth gets

compact and strong. In such cases, it would be enough to make the wells *pakka* down to this level.

BHAGALPUR.

General description.—Bhagalpur is divided into two separate portions by the river Ganges. The north, consisting of the subdivisions of Supaul and Madhipura and part of the Sadr subdivision, is alluvial, and is low and subject to inundation, the only high lands being ridges on the banks of the rivers, from where there is a gradual decline towards the interior. Immediately south of the Ganges the land still remains low. Up to this border, rice forms the all-important crop. Further south, rather higher lands are again to be found which are suitable for the growing of *rabi* crops and such special crops as sugarcane and poppy. Here rock of different formations is to be found.

Rainfall.—The normal rainfall amounts to 51·29 inches. Variations in the actual fall during the last ten years range from 34·86 inches to 72·62 inches, as will be seen from the following figures :—

Year.		Actual fall in inches.	Year.		Actual fall in inches.
1896	...	37·09	1901	...	34·86
1897	...	50·98	1902	...	51·64
1898	...	51·22	1903	...	40·62
1899	...	72·62	1904	...	53·34
1900	...	59·24	1905	...	66·45

Population, material condition, emigration.—The area of the district is 4,226 square miles, and the population 2,088,953, or 494 to the square mile. This is lower than Monghyr. The agriculturists (1,416,015) bear about the same percentage (67·78) to the total population as in Monghyr (65·83), and they show a density of 455 persons to a square mile of cultivated area. This low figure points rather to scarcity of labour. In this respect, Bhagalpur is worse off than most of the other districts of Bihar. As a class, the cultivators are fairly laborious and intelligent. The Sonthals, who are found mainly in the subdivision of Banka, are indolent, like the rest of them who are to be found in other parts of the Bhagalpur division and in Chota Nagpur.

Cultivation.—The percentage of net cropped to total area is 73·60, against 41·48 per cent. in Monghyr and 42·64 per cent. in the Sonthal Parganas. In this area rice forms the chief crop, with a percentage of 72·98, while *rabi* has only a percentage of 36·57. The extension of the latter area with well irrigation may well be advocated, and the same kind of irrigation may be developed for sugarcane which occupies nearly 3 per cent. of the net cropped area. Opium is very little grown, and does not make any demand on well water.

Irrigation.—As in North Monghyr, so in North Bhagalpur, irrigation is not generally necessary as the land is mostly liable to floods and is sown with rice. In some of the upland ridges, wells would undoubtedly prove useful, *e.g.*, in the Supaul subdivision, where water is found at a depth of 10 to 12 feet below the surface and where the land is not subject to inundation. Here and in similar places in North Bhagalpur, excepting Madhipura, which is very liable to inundation from the river Kosi, *kachcha* wells may well be sunk for *rabi* crops and the area and outturn of such crops be thus increased. It is reported that the chief reason why wells are not used here is that rents are low and *raiya*s are satisfied with very little.

For South Bhagalpur, wells are a greater necessity. The lands are suitable for *rabi* crops, which, without irrigation, do not yield much of an outturn at present. The standing *rabi* crops seen by me in these parts in the beginning of the hot weather had a most withered and scorched appearance. In very many places, the water level is such as would allow of sinking permanent wells at a moderate cost. An average of 30 feet is to be found in many places, though the variations are so great that within a few hundred yards water will be found in some places at a depth of 10 feet, and in others not till a depth of 40 feet is reached. It is on this account, that it is very difficult to suggest any particular location of wells. But after my enquiries and consultation with local officers, zamindars and tenants, I think that the

sinking of permanent wells is capable of being extended in many parts of South Bhagalpur.

The *raiya*s report, that at depths varying from 30 to 60 feet, a layer of *kankar* is to be found, about 4 feet in thickness. This is in all probability the *tawa* or *mota* layer, which should be always looked for in sinking permanent wells.

The hilly portion of Banka may be excluded for the present from the field of operations, as it consists of hard rocky tracts, which are sparsely populated and in which water is not generally found until 60 feet of hard strata are pierced through. But the whole of Amarpur thana in this subdivision affords scope for well sinking. In this view, I have the support of Mr. Hossein, the Subdivisional Officer of Banka, who takes a great interest in the subject. Sugarcane is the only crop that is irrigated here now. *Rabi* crops are grown, and for them artificial irrigation from wells would prove most beneficial. Irrigation from wells in homestead lands round about villages may be also extended in the district with benefit. Such irrigation seemed to be rarer in Bhagalpur than in other neighbouring districts of Bihar.

The Collector was of opinion that well irrigation cannot be pushed on in the Wards and Government estates of the district. The latter lie mostly in *diara* lands.

Mots and *dhenkals* are the two lifts in common use, the latter being much more popular with the *raiya*s. Both these kinds of lifts could very well be used in all parts of the district.

SONTHAL PARGANAS.

General description.—The alluvial tracts excepted, the lands broadly show the same classification as those of Chota Nagpur. First of all, there are the low-lying lands of the valleys, which are terraced for rice cultivation (a system of cultivation which will be found described in full in the notices of the Chota Nagpur districts further on), and then there are the uplands (*bari*) near the homestead, which grow all kinds of *bhadoi* and *rabi* crops. The rice lands, as in other districts of the same configuration, are irrigated from perennial springs, but more generally from water stored by throwing embankments across the natural depressions and hollows of the country, and wells therefore are not required. As in Ranchi and similar districts, the lowest hollows are the most fertile, as they receive the water from the upper terraces, so that they are able to retain moisture during the driest years. As the terraces ascend, naturally they get less and less water and are therefore more susceptible to drought. On the best rice lands two crops are grown, gram, *khesari* and other *rabi* crops being taken as the second crop. The *bari* lands also consist of soils of different degrees of fertility. Those immediately adjoining the village are the best. Manure and well-irrigation are supplied here to the exclusion of lands lying further from the village. But irrigation is never sufficient in these *bari* lands. The number of wells require to be increased, and to spread away gradually from the village. The best *bari* lands generally give two crops, the first crop being *maize*.

Rainfall.—The rainfall in the Sonthal Parganas is high, the normal being 58·86 inches. It is this plentiful rain, and the peculiar configuration of the country which admits of it being suitably stored and distributed, that is the salvation of the rice crop, which is the main stay of the country. The table given below shows the fall in each of the past ten years:—

Year.		Actual fall in inches.	Year.		Actual fall in inches.
1896	...	47·08	1901	...	42·56
1897	...	54·17	1902	...	54·13
1898	...	56·20	1903	...	44·30
1899	...	64·31	1904	...	54·15
1900	...	52·62	1905	...	62·12

The figures show, that the rainfall bears a closer resemblance to that of Chota Nagpur in its comparative uniformity than to the districts of Bihar, where the variations in the actual from the normal fall are very great.

Population, material condition, emigration.—The density of population in the Sonthal Parganas is greater than in some of the other hilly districts of Bengal. With a total area of 5,470 square miles, and a total population of 1,809,737 souls, the density amounts to 331 persons per square mile. This is a low figure as compared with Bihar districts, but this is due to the considerable areas of uninhabited or sparsely inhabited jungle and hills.

There is a fairly considerable amount of emigration to Assam and the Duars; but in spite of this, labour is on the whole not scarce. The greater portion of the people are altogether dependent upon agriculture. Statistics of the last Census Report show that agriculturists form 80 per cent. of the total population; and of them there are 624 to every square mile of the cultivated area (1,492,700 acres). There is thus no lack of labour in the district to undertake high cultivation and to push on well-irrigation.

The character of the people is practically represented by the aboriginal and semi-aboriginal races, who form the bulk of the population. Like their brethren, who are found in other districts, they are, as a rule, thriftless and idle, and much given to intoxicating liquors, so that much time which could better be given to the improvement of cultivation is frittered away unprofitably.

Famine, scarcity, drought, &c.—Owing to the undulating character of the district and the high normal rainfall, a complete failure of crops is impossible; but in a dry year, there is always a risk of a partial failure of crops, which affects the whole district alike, and it is for the prevention of this that the extension of irrigation is necessary.

Cultivation.—Owing to the hilly and jungly character of the country, the net cropped area is low, being 42·6 per cent. of the total area; but it is higher than that of Ranchi and Palamau, the physical aspects of which districts are somewhat similar. The rice area, though less cultivated than in Ranchi, is a more important crop than in Palamau. It covers 60 per cent. of the net cropped area and certainly forms the chief crop of the district. For its preservation, *bunds* are necessary, and their construction in the district must be encouraged. *Rabi* crops take up 27·31 per cent. and *bhadoi* crops, exclusive of rice, 28·64 per cent. of the cropped area. As regards its *rabi* area, the district takes an intermediate place between Ranchi and Palamau, the corresponding figures for which districts are 5 per cent. and 41 per cent., respectively. Sugarcane is scarcely to be seen, and opium has not entered the district. There is much land available for the introduction of sugarcane and opium, and for the extension of the *rabi* area. What is wanted is a sustained scheme for the development of well-irrigation.

Irrigation.—Wells may be said to be almost absent from the irrigation system of the Sonthal Parganas. Settlement records show that in the tracts which have been surveyed recently, comprising an area of 3,492 square miles, the area irrigated from wells forms only ·005 of the net cropped area, and ·09 per cent. of the total irrigated area, which in itself bears the low percentage of 6·12 to the net cropped area. All the irrigation that exists in the district is from perennial springs, or is effected by *bunds* or small embankments thrown across the narrower ends of the trough-like depressions which occur all over the country, and which are made to store the water for crops in reservoirs called *ahars*. In the surveyed tracts, the area irrigated from tanks and *ahars* occupy 2·02 per cent. of the net cropped, and 32·97 of the total irrigated area. The embankments and *ahars* have been made for the most part by the *raiylats* individually or as village communities. It will be interesting here to note how co-operation among cultivators has become easy in the district. In an official report perused by me in the Deputy Commissioner's office, I found it stated that in the Sonthal Parganas the unit is the village. Every village almost has its own headman who, as the representative of the villagers, deals with the proprietor, who is only a rent-receiver, and has nothing to do with the improvements being conducted in the village. If he offers any obstacles in the matter, he is liable to be brought up before the District Officer. Cultivators therefore have not to fear their landlord when making improvements; and under the laws in force in the district, they need fear no increase in rent for improvements till a resettlement is made of these tracts by Government, which is generally done after long periods and very often does not result in an increase of rent. Thus it is that in the matter of irrigation, they have combined together and have

fully taken advantage of the natural irrigational advantages of the district to throw *bunds* across the dips of the district to get water for their rice crop. Singly, they could not have afforded to do this on any proper scale, but as a body, they have been able to afford not only to make these embankments but to maintain them in good condition. With such co-operation, therefore, it appears very probable to me, that much could be effected by giving loans to cultivators for the digging of wells also. Some of the local officers, I found, viewed askance the idea of well sinking, but I must add that I am more hopeful. I have had it from the *raiyats* themselves, that should more wells be sunk in the district, the *rabi* area would increase. Of course, it must be granted that in rocky soils the cost of digging permanent wells becomes expensive, and in fact out of the question for the individual cultivator, but where the co-operative spirit described above exists, this difficulty does not arise, and it should be taken advantage of to improve the cultivation of the country. It may be urged as an objection that *bunds* would improve larger areas of land, but I am of opinion, in which I am supported by the *dictum* of most cultivators, that *bund* water would not be as useful as well water for increasing the outturn of valuable crops, and especially of *rabi* crops and moreover well water would help in extending the *rabi* area. It is an expansion of this area that is wanted for the district, and I therefore strongly urge that, wherever possible, wells should be sunk. The particular localities in which a beginning may be made will be mentioned below. First of all the depth at which water is to be found may be noticed. As a rule, *kachcha* wells have to be dug 15 to 25 feet deep before water can be found. In such wells, 8 to 12 feet of water would be found throughout the cold weather. They would therefore be always useful for the cultivation of *rabi* crops. Their cost of construction was locally estimated to vary from Rs. 5 to Rs. 20. In the hot weather, they dry up altogether, but I was informed by some *Koeris* of the district, that when such is the case, they find it possible with the character of the substrata in certain parts to re-excavate, so that the same well answers for the irrigation of both hot weather and cold weather vegetables. For permanent *pakka* wells, a greater depth would have to be pierced. From several measurements taken by me, I found that their depth varied from 25 feet to 40 feet. Most of them I saw had no water in the month of June. They are said generally to dry up in May, when there has not been an excess of rain in the previous winter season, but I was informed by many experienced *raiyats* that there are permanent wells to be found which retain water throughout the year. Their cost varies ordinarily from Rs. 150 to Rs. 300.

The lever lift with manual labour is in general use in the district, but bullock labour is to be found in some few villages in north Godda.

To sum up now as stated above, perennial springs supply a great deal of moisture for ricelands. Rice is moreover irrigated from water reservoirs formed by *bunds*; wells are scarce. For drinking purposes, *kachcha* wells are made in villages over the site of surface springs. These are very shallow, and besides being utilized as drinking wells, they supply water for tobacco and vegetable crops, which are grown in small patches on homestead lands. As a rule, the site of these wells is not selected with any care, and when dug they are much neglected. The water is lifted by simply letting down a rope with a little drinking vessel attached to it and then drawing it up. There is no reason why such wells, constructed on a larger scale, should not supply sufficient water for all kinds of *rabi* crops.

In the north of the Godda subdivision, which is flat, there are some wells from which isolated plots of land containing winter crops are irrigated. I have seen a little sugarcane, and some wheat, and tobacco being irrigated here. Bullock labour for lifting water was also found in some few villages. Well irrigation should, in my opinion be largely extended in these villages. The conditions here approximate to those of Bihar, and well sinking should not, therefore, be found difficult. The extension of wells is also recommended for all the flat lying portions of the district. There are many such tracts in patches in the Rajmahal, Pakour, Deoghar and Jamtara subdivisions. At present in the district, the largest number of wells are found in the *zamindari* portions of Rajmahal and Pakour, but 90 per cent. of these are *kachcha* wells. Some permanent wells would prove useful here. The cultivation of sugarcane is reported to be increasing in the district, and Mr. W. H. Thomson, the Subdivisional Officer of Dumka, who is

generally opposed to the sinking of wells in the Sonthal Parganas, thinks there are solvent cultivators who could be got to make wells in *bari* lands for the growth of this crop. The Government *Khas-mahal* Daman-i-koh, covers a good portion of the district, and the sinking of wells should certainly be started first of all in this estate. The Court of Wards' Estates comprise 550 square miles, and they also offer a field for well construction. Of course, for the district as a whole, considering the peculiar configuration of the country, it appears to me that large schemes of improvements are required for the extension of the system of *bunding*, which is now being done on a small scale, according to their limited means by the cultivators themselves.

RANCHI.

General description.—The district of Ranchi comprises an area of 7,128 square miles. In its physical aspects, it differs altogether from the adjoining districts of Bengal. Ranges of hills, having usually an east and west direction, traverse the district. The central tableland, comprising most of the district, has an elevation of about 2,000 feet. There are isolated tracts which in parts are less than 1,000 feet above sea level, and others attain an elevation of 3,000 feet and more. Owing to the rocky character of the country, the cultivated area also presents an appearance different to that to be seen in the alluvial districts of Bengal. The lands are broken up into two distinct classes. First, are the low lands which are formed in the valleys intervening between continuous ridges of uplands. These have been terraced by cutting into the slopes of the hills leading to the valleys. Then come the village uplands, known generally as *tanr* lands. The best of the low lands are those which lie at the bottom of the valley. Some of them have perennial springs and remain perpetually moist. There is no need of artificial irrigation here as the natural springs are sufficient to produce most valuable crops of rice. The *tanr* uplands are of different degrees of fertility according to their situation with respect to the village. Those in the village itself known as *bari* lands are the most fertile and are used for growing maize, tobacco, various vegetables and other crops which require special labour and care. The lands are sometimes fertile enough to give a second crop after the maize. Lands which immediately adjoin the homestead come next in point of fertility. Only the more valuable among *bhadoi* crops are grown here as well as all kinds of *rabi* crops. The outlying uplands are grown with upland rice and such *bhadoi* crops as do not require much labour.

Rainfall.—The normal rainfall is 53·53 inches. In some years, the rainfall has exceeded 60 inches. It is this heavy rain that is the salvation of the rice crop in Ranchi. As in the Sonthal Parganas, no water is obtained for this crop from rivers or other artificial sources, but the rain which falls is carefully stored by a system of terracing. The rainy season is very irregular in its break and in its close. The amount of rain received in each year for the last ten years is as follows:—

Year.		Actual fall in inches.	Year.		Actual fall in inches
1896	...	... 46·42	1901	...	... 54·82
1897	...	... 52·05	1902	...	... 45·50
1898	...	... 53·00	1903	...	... 54·46
1899	...	... 39·77	1904	...	... 68·32
1900	...	... 59·36	1905	...	... 46·72

The variations in the annual fall are not very marked, but in the months of July and August, when the best rain is received for low land paddy and for all the *bhadoi* crops, the fall over a series of years has been found to vary from 4 and 8 inches to 19 and 28 inches.

Population, material condition, emigration.—Ranchi, according to the last Census, shows a density of population of 166 persons per square mile. In spite of the light population, the agricultural resources of the country are very poor, and it is said that the total produce of cultivation is not sufficient to furnish the *raiyats* with full rations all the year round. The Census Report of 1901 shows that nearly 80 per cent. of the population are agriculturists; but in this district, more than in others, almost all the inhabitants are wholly or partially dependent

on agriculture. The pure agriculturists, according to the same Census, show a density of 402 persons to every square mile of the country under cultivation, which is decidedly lower than in Bihar. The cultivation of lands in Chota Nagpur, whether by Hindus or by aboriginal tribes, is much less careful than in Bengal and Bihar. The local people, with the exception of some Hindus, prominent among whom are the *Koeris*, and of some *Kols*, who show diligence in all kinds of earthwork, especially in the preparation of rice lands by cutting into the slopes of the hills, are indolent and poor, and devoid of any foresight. The *Kols* themselves are much addicted to drink. Labour has become more scarce from emigration also, which is so prominent a feature of Chota Nagpur, and this no doubt has told prejudicially on the cultivation. The inhabitants of the district themselves say that, although prices have risen in many years, they have never felt the pinch of a severe famine. This is specially true of the central plateau of Chota Nagpur, which forms the main portion of the Ranchi district. Rice which grows on the lowest lands of the valleys here has always moisture and water sufficient for an ordinarily good crop. The higher terraced lands may get dry in a year of deficient rainfall, but there is always water present in the lowest hollows, so that a year of drought can only affect the paddy crop to a certain extent. This is no doubt one of the reasons, which makes the Ranchi cultivator indifferent to the growing of a variety of crops and to providing for irrigation to ensure the production of such crops. He is content with what he knows he will get from his low-lying paddy lands. Drought which is always the most common cause of famine does not seriously affect Ranchi. Excessive and continuous rain also has no marked injurious effect. The undulating nature of the country gives it a more or less perfect drainage, so that there is no fear of water logging. In isolated tracts below this well-protected central plateau, on the north and east, the country is more liable to famine as the cultivated lands here lie on the higher slopes of the hills, and are likely to have their crops damaged by an early cessation of the monsoon. Moreover, the lands are heavier than those of the central plateau and are therefore more liable to suffer in a year of excessive rain. The Deputy Commissioner has very kindly supplied me with a famine map, in which the Ranchi, Basia Kolchira, Kochediga, and Kurdeg Police circles are left uncoloured, showing that they are absolutely immune from famine. The other parts of the district are considered to be more or less liable to famine in very bad years. From all enquiries made by me, it would appear that the Silli and Tamar thanas are those likely to be first affected in a year of drought.

Cultivation.—The net cropped area, which comprises 1,475,100 acres, occupies only 32·4 per cent. of the total district area. This is to be partially expected from the rocky and hilly nature of the country. But there is still great room for the extension of cultivation. Its limited area is a great deal due to the ignorance, indolence and intemperance of the peasantry, most of whom, especially the aboriginal tribes, who form the bulk of the population, are quite content to lead a happy-go-lucky life without any foresight or thought of the future.

Rice is the main crop of the district occupying 90 per cent. of the net cropped area. The *rabi* area takes up only about 5 per cent. of the net cropped area. It would seem, that under such circumstances, well-irrigation is not at all necessary; but it is to this very irrigation that we must look for the extension of the *rabi* area. An extension of this area and an increase in the variety of crops is required to supplement the food-supply of the district.

Irrigation.—The use of well water for irrigation is very limited in Ranchi. In the area, which has been recently surveyed in thanas Khunti, Tamar, Bundu and Rahi, comprising 992 square miles, Settlement records show the total irrigated area to be only ·19 per cent. of the net cropped area. The sources of water available are from tanks, *ahars*, *daris* and wells. Tanks are very few in number, and those that exist are used only for drinking purposes, *Ahars* also are not numerous; but wherever they exist, they are considered a great boon by the cultivators. Those thrown across the hollows are specially useful for rice, as when the embankments of the higher terraced lands breach, the stored water gradually percolates over the lower terraces, which are thus kept moist when there is a break in the rains. Like those, thrown across streams,

they can be utilized also for all spring crops. At present, they are solely used for paddy. *Daris* are natural surface springs, which are found scattered over the district. They are used for drinking purposes and not for irrigation. Wells also are very rare, and are used only by *Koeris* for the cultivation of tobacco, sugarcane and vegetable crops. The various sources of irrigation in the surveyed tracts referred to above and the extent to which they are utilized for crops will become apparent from the figures now given, which may be taken as more or less representative of the whole district:—

	Total area.	Net cropped area.	Per cent. to total area.	Total irrigated area.	Per cent. to net cropped area.	SOURCES OF IRRIGATION.										Irrigated from other sources.	Per cent. to net cropped
						Irrigated from wells.	Per cent. to net cropped area.	Per cent. to total irrigated area.	Irrigated from private canals.	Per cent. to net cropped area.	Per cent. to total irrigated area.	Irrigated from tanks and <i>ahars</i> .	Per cent. to net cropped area.	Per cent. to total irrigated area.	Irrigated from other sources.		
Ranchi comprising thanas Chhanti, Tamar, Bundu and Rahl.	635,264'85	313,254'84	49'31	556'83	0'19	99'10	0'03	10'81	..	...	...	142'08	10'04	24'19	345'65	0'	0'

The figures tend to show, that the district is in sore need of the extension of irrigation. The food supply requires to be increased, and this can only be done by supplementing the rice crop by a variety of other crops, and especially spring crops. The cultivation of the latter crops is limited, simply for the want of proper provision for irrigation. The crops are also of an inferior character due chiefly to the want of irrigation.

The question now arises, what mode of irrigation is best for a country like Ranchi with its rocky and undulating character, with its poor river system and with its thriftless population. Large irrigation canals are out of the question as the supply of the largest rivers in the district are not sufficient to feed them throughout the year. Huge irrigation reservoirs, which can only be constructed at very heavy expenditure are out of the reach of the *raiyat*, and in Ranchi practically out of the reach of the *zamindar* also, who is generally steeped in debt. It is therefore to small *ahars* and wells, that we must look for the extension of irrigation. Local opinion is in favour of the former, and so far I acquiesce in this opinion, that owing to the undulating nature of the country, it is possible to construct an unlimited number of such embankments at a small cost. But this does not mean, that there is no room for well-irrigation also. In the first place, I am of opinion that it is possible to convert the *daris* into wells. They are fairly well scattered over different parts of the district, and if excavated to a depth of 12 to 20 feet, should supply sufficient water for spring crops. Then again, on account of the undulating character of the country, when the rain ceases early, the standing crops on the slopes of the higher (*don*) lands dry up for want of moisture. *Kachcha* wells 10 to 12 feet deep may be usefully dug here at a cost varying from Rs. 3 to Rs. 20. On flat ground, such as is to be found in the eastern part of the district known as the Five Parganas, which is situated near the beds of rivers, or down the lower sides of tanks, *kachcha* wells, if sunk, would receive sufficient water by percolation. Such percolation wells, as a matter of fact, exist here, but their number is limited and they are at present only used for a few crops by *Koeris*. Their extension would undoubtedly lead to an improvement in the outturn of crops and to an increase in their variety. Cultivators, other than *Koeris*, find it evidently too laborious to utilize well water for their crops, though the sole reason alleged by them for not using it, is that it is not the practice in the district to use such water. The construction of *pakka* wells in Ranchi, on the other hand, must be admitted to be a matter of some difficulty, but such wells are by no means impossible. It is quite true, that, the rocky nature of the substrata, which are very variable, and the great and varying depths at which a permanent supply of water for spring wells may be found, furnish obstacles to the general construction of *pakka* wells, but I would certainly suggest that some such wells be dug in suitable lands.

Both in the matter of *kachcha* and *pakka* wells, there is no particular part of the district which can be said to be more suitable for wells than others. Their construction may be commenced in the tracts which have been mentioned in a previous paragraph to be those in which famine would first be felt, should famine visit the district at all. The lands in which *kachcha* wells can be usefully sunk have already been indicated. Many of these lands, however, contain a rather loose soil. In such cases, it would be wise to protect them with some kind of masonry work. A lining of bricks without mortar would be sufficient. Permanent wells can be sunk in the *tanr* uplands, where the best spring crops are generally grown. Here, the depth of water varies from 30 to 50 feet. The cost of such wells, when rock has to be blasted may reach up to four figures, but ordinary permanent wells on low lands would not cost more than Rs. 100 while the cost of those on high lands would vary from Rs. 200 to Rs. 500.

There are four Government and four Wards Estates in the district. Nothing has been done in them yet in the matter of well-irrigation. A beginning might be made here as has been done in Palamau, where Government has been digging a few wells in its estates for the last three years.

The *mot* is very uncommon. The only lift, I saw in the district even in very deep wells was the *latha kundi* (lever bucket) which in some cases was of unusual proportions. The labour in such instances becomes very great, and the *mot* should certainly replace the *latha* over all deep wells.

Another fact, which requires mentioning here, is that in Ranchi wells do not contain sufficient water for irrigation throughout the year, but water is always to be found in the months in which it is required for most spring crops, so that their scanty supply at the latter end of the dry season is not sufficient argument against their construction. Where proper springs occur, this inconvenience would not be experienced at all.

PALAMAU.

General description.—Palamau, with an area of 4,905 square miles, comprises a hilly and broken country, covered for the most part with low jungle. There are numerous spurs in the south and east, which are thrown off from the plateaus of Hazaribagh and Chota Nagpur, and in the west is the high tableland of Sirguja. In the north, the physical aspects resemble those of the adjoining districts of Gaya and Shahabad. A greater portion of the soil here is of alluvial origin, and presents a highly-cultivated appearance, and the methods of cultivation and the character of the people do not differ much from what are to be found in Gaya and Shahabad. Like Ranchi, the district is cut up by a large number of small streams, which, though in flood during the rains, contain little or no water during the dry season.

Rainfall.—The normal rainfall is less than that of Ranchi, being only 48·17 inches. The actual fall for each of the last ten years has been as follows:—

Year.		Actual fall in inches.	Year.		Actual fall in inches.
1896	...	34·82	1901	...	40·07
1897	...	48·67	1902	...	34·51
1898	...	49·79	1903	...	31·45
1899	...	41·03	1904	...	47·59
1900	...	55·22	1905	...	50·86

The rainfall from year to year is more variable than in Ranchi. In its distribution throughout the year, it is also very unequal. In some months, especially in September and October, there is an abnormal deficiency, which is bad both for the paddy which has already been sown, and for the *rabi* which is yet to be sown.

Population, material condition, emigration.—With an area of 4,912 square miles and a total population at the last Census of 619,600, the density of the population comes to only 126 persons to the square mile. The agricultural population consists of 242,669 souls, and the density of population per

square mile of the net cropped area (688 square miles) amounts to 353 persons. It would thus seem that the pressure of the population on the soil is less than in Ranchi. Unlike the latter district, the Hindu element in Palamau preponderates over the aboriginal population. The former are found in the northern parts of the district where cultivation is more advanced; while the latter muster strong in the south adjoining Ranchi. The remarks made regarding the character and material condition of the people in Ranchi apply to Palamau. The best cultivators are the *Kæris*. With the Rajputs, they go in largely for high cultivation, which requires both skill and heavy labour, while the purely aboriginal tribes are content with the raising of crops that require comparatively less manual labour. In the matter of indebtedness, it is reported that the *rai-yats* are worse off generally than those of Ranchi. The Hindus inhabiting the fertile river valleys of the north are fairly prosperous, but as a rule they also live a hand-to-mouth existence.

Emigration from Palamau is much less than that from Ranchi, the chief emigrants being the aborigines living in the south of the district. Immigration has no importance now in Palamau. In this respect, it resembles Ranchi. The Hindus who are found in these two districts came into them some years ago, and the inflow of immigrants has now ceased, the reason being that most of the fertile lands have been taken up, and the hilly and jungly tracts are the only portions that are now open to foreigners.

Famine, scarcity, drought, &c.—Palamau is much more liable to famine than Ranchi. A drought affects it more seriously owing to the absence of water holding depressions which are typical of the sister district. The rice lands, whether situated high or low, are much more level than those of Ranchi, and are therefore much more readily affected by drought. In a season of short rains, there also crops up the disadvantage of a want of moisture for the successful cultivation of *rabi* crops. Irrigation is therefore more needed for Palamau than for Ranchi.

Cultivation.—The net cropped area consists only of 440,500 acres, which means that it comprises only 14 per cent. of the total area of the district—a figure much lower even than that of Ranchi. It will be apparent therefore, that a vast area of land is available for cultivation, and while the hilly character of the country makes cultivation difficult, there can be no doubt that in an extension of irrigation will be found at least a partial solution of the difficulty. By a suitable supply of irrigation water, much cultivable jungle could be reclaimed. In the cultivated area, rice does not hold the same importance as in Ranchi. It comprises an area of 163,000 acres, which is only 37 per cent. of the total net cropped area against a corresponding percentage of 90 in Ranchi. The *rabi* area (180,500 acres), on the other hand, takes up 41 per cent. of the net cropped area, against only 5 per cent. of the net cropped area in Ranchi. While, therefore, wells may not be as distinctly necessary here as in Ranchi for extending the actual area under *rabi* crops, they are more urgently required for bringing these very crops to a higher condition than they attain at present without irrigation. Sugarcane occupies a small area, and opium is altogether new to the district, being hitherto tried only experimentally. No doubt, the construction of wells would lead to an extension of the areas under both of these important crops.

Irrigation.—The existing sources of irrigation are *ahars* or reservoirs, wells, rivers, hill streams and tanks. The utility of *ahars* has been emphasized in my notice of the husbandry of Ranchi. It holds as important a place in the arable cultivation of Palamau. It is indispensable for the cultivation of paddy. In Ranchi, the lowest paddy lands can partially withstand the bad effects of a dry season, even in the absence of sufficient provision for irrigation, but drought in Palamau without irrigation means a total failure of the paddy crop, which, although occupying a very small percentage of the net cropped area as compared with the rice area of Ranchi, is still the most important single food-crop of the district, and as such requires to be saved. The necessity of making *bunds* and *ahars* therefore and keeping them in repair must not be underrated. If they are kept full, there would be no fear of a failure of the rice crop, and they would also benefit the wheat and barley crops in the following *rabi* season. *Ahars* abound in the district, but a very large proportion of them have become nearly useless for want of repair, which no

doubt accounts for the present short outturn of paddy. Any money spent on them would undoubtedly lead to an improvement of the agriculture of the district. Without overlooking the utility of *ahars*, improvement must be sought for in other sources of irrigation also. River streams and tanks, which are at present seldom utilized for watering crops, do not commend themselves to me as useful sources of irrigation. Wells may, therefore, be used to supplement the irrigation from *ahars*. They are distinctly required for the *rabi* crops, which occupy an area larger than that of rice.

There are no statistics available to show the extent of irrigation and of different kinds of irrigation in the entire district, but the following figures, which are taken from the Final Report on the Survey and Settlement of the Palamau Government estates, will throw some light on the subject. The report relates to an area of 272,000 acres, containing a net cropped area of 56,278 acres. The total irrigated portion of this area, comprises 8,558 acres, which amounts to 3 per cent. of the total area, and to 15 per cent. of the net cropped area. These figures are very low, and if accepted as representative of the whole district, would show the real need for irrigation. Turning now to the different sources of irrigation, it is stated that of the irrigated area shown above, 7,759 acres receive their water from *ahars*, 412 acres from other sources, and 386 from wells, so that while 90 per cent. of the total irrigation is from *ahars*, only $4\frac{1}{2}$ per cent. is from wells. If these figures, again, be accepted as giving some idea of the present existing conditions of irrigation in the district, the necessity for the extension of well-irrigation becomes clear. The well-irrigational conditions that prevail over the district are, in my opinion, even worse than what is disclosed by the Settlement records. I was informed at Palamau, that at the time of the sittings of the Irrigation Commission, a rough estimate of only 6 per cent. of the total area was made, as representing the proportion of land irrigated from wells. At present, it is reported that the largest number of wells are to be found in thanas Husainabad, Garhwa, Paton and Daltonganj. They are both *pakka* and *kachcha* and are chiefly used for sugarcane fields. In village sites in these thanas, almost all vegetable crops receive water from wells. I would recommend, that the construction of wells be commenced in these thanas at the outset. They lie along the valleys of the Amanat and Koel rivers, and contain soils quite suitable for well-sinking. Where rock occurs, the work of construction may be deferred till the cultivators get more familiar with the advantages to be derived from using well-water for irrigation.

The Deputy Commissioner has informed me that in the Government estates which occupy an area of 425 square miles, something has been done in the way of well-construction during the last three years. The amount spent annually has however in no year exceeded Rs. 4,500, and the work is therefore capable of further development. The Deputy Commissioner is of this opinion too. The estates lie scattered over the district, and suitable sites should therefore be readily found. Some local officers view with disfavour the introduction of wells on any large scale in Palamau, but while in the district, I came across many cultivators who took a contrary view of the matter. *Kachcha* wells have not the objection of a heavy initial outlay, and they could be very well largely extended in the tracts mentioned above.

In lowlying tracts, water can be found at a depth of 15 feet below the surface. For a perennial supply of water, it would be necessary to go down to a depth of 40 to 50 feet. The cost of digging *kachcha* wells in the district was stated in different places to vary from Rs. 5 to Rs. 15. These wells would be about 15 to 20 feet deep. The estimates of *pakka* wells varied from Rs. 150 to Rs. 300. The *latha kundi* is the almost universal water-lift. One comes across a *mot* now and again. Both these lifts suit the district, the one for shallow and the other for deep wells.

PATNA.

General description.—The district may be described generally as an alluvial plain. There is a small area of hill in the south. All along the banks of the Ganges, splendid crops are produced. The soils of the district are those to be generally found in alluvial formations, consisting of admixtures of sand and clay in different proportions.

Rainfall.—The normal rainfall of Patna is 45·25 inches. This is lower than that of the North Bihar districts, excepting Saran which has a normal fall of 45·04 inches. The rain which has been received for the last ten years is shown in the subjoined statement :—

Year.		Actual fall in inches.	Year.		Actual fall in inches.
1896	...	31·74	1901	...	37·68
1897	...	55·50	1902	...	35·63
1898	...	60·35	1903	...	24·35
1899	...	55·86	1904	...	47·41
1900	...	40·84	1905	...	48·47

The variations in the actual fall are similar to those in the North Bihar districts.

Population,* material condition, emigration.—Patna contains a population of 1,624,985 persons and a total area of 2,075 square miles, and the density of population is thus 783 persons per square mile, which is much denser than in Shahabad or Gaya. The total number of agriculturists was shown in the last Census as 984,691, forming 60·59 per cent. of the total population, and giving a density of 584 agriculturists to every square mile of the net cultivated area (1,686 square miles). The condition of the people compares favourably with that of most other Bihar districts. In ordinary years, the cultivators are quite sure of large returns owing to the natural fertility of the soil, and even in bad years, distress is not severely felt in the district owing to its excellent communications.

Famine, scarcity, drought, &c.—Rice is the main crop of the district, but the *rabi* area is comparatively very large, and a good *rabi* harvest is certain to stave off the distress following a failure of the winter rice harvest. This, in fact, has been the experience of the district. Should famine at all invade the district, it would first touch the Barh and Bihar subdivisions. Here it is, that artificial irrigation is especially needed.

Cultivation.—The net cropped area forms 81·2 per cent. of the total area of the district. Of the former area, 45·3 per cent. is occupied by rice, 42·7 per cent. by *rabi* and 21·3 per cent. by *bhadoi* crops (exclusive of rice). Sugarcane and opium both occupy fairly large areas.

The *rabi* area is almost as important as the area under rice, though the latter is the main staple food-crop of the population.

Irrigation.—On the whole, the district may be said to be fairly well irrigated. There are very low marshy lands on which paddy grows, which do not require irrigation, and there are other small tracts which are annually flooded and are saved the necessity of being watered. But in the rest of the district, there is still much scope for irrigation. The western end is supplied by the Patna canal and its distributaries. *Ahars*, artificial water-courses and small streams form also an important source of supply. They are found all over the district, but especially in the subdivision of Bihar. Well-irrigation has been known in Patna from time immemorial, and wells also are dug all over the district, where energy and money is forthcoming. Both *pakka* and *kachcha* wells are to be found, but the latter predominate, being chiefly used for the cultivation of poppy, sugarcane, potatoes and vegetables. Round about the town of Bihar, they are very common, and so are they very numerous round about Bankipore. Between this station and Digha Ghât, the *latha* (i.e., the lever bucket) strikes the eye of every observer. Wells are to be found also in all parts of the Sadr and Dinapore subdivisions and in the Eastern portion of the Barh subdivision. But there is still room for their extension, more or less throughout these portions of the district, which are not commanded by the Patna canal. They would be especially useful in the interior of the Bihar subdivision and in the southern portion of the Barh subdivision. In the Mokameh thana of this subdivision, it is stated, that the large tract of country known as *tâl* lands suffer very much from scarcity of water during the dry season. Within this tract, which comprises an estimated area of about 350 square miles, wells are very necessary.

Some statistics of irrigation obtained from the Settlement papers of those tracts of the district, which have been recently surveyed, are subjoined as being of some interest :—

	Total area.	Net cropped area.	Per-centage to total area.	Total irrigat-ed area.	Per-centage to net cropped area.	SOURCES OF IRRIGATION.								
						Irrigated from Govern-ment canals.	Percentage to net crop-ped area.	Percentage to total irri-gated area.	Irrigated from private canals.	Percentage to net crop-ped area.	Percentage to total irri-gated area.	Irrigated from tanks, wells, etc.	Percentage to net crop-ped area.	Percentage to total irri-gated area.
Patna ...	Acres. 63,535	Acres. 30,386	47·82	Acres. 2,970	9·44	Acres. 31	0·10	1·08	Acres. 300	0·99	10·45	Acres. 2,538	8·35	88·43

The figures above show, that the total irrigated area within the surveyed tracts is $9\frac{1}{2}$ per cent. of the net cropped area, and that the area irrigated from *ahars*, wells, tanks, etc., is from 8·35 per cent. of the net cropped area to 88·43 per cent. of the total irrigated area.

The water-level varies in different places. In *kachcha* wells, water is found at 10 to 15 feet below the ground. I am informed, that in the tract south of the Sadr and Dinapore subdivisions, stretching from Araria in Bankipore to Mahabalipur on the Sone and lying south of Khagaul and Phulwari, which is the old abandoned bed of the Sone, the wells are still supplied by springs; but in other parts of the district, they are generally supplied by percolation. In my opinion, deeper digging is likely to disclose springs in most parts of the district. In the Barh and Bihar subdivisions, the average depth of masonry wells is 30 feet, and in the Sadr and Dinapore subdivisions, 40 feet. In some parts of Bihar, wells are not deeper than 25 feet, while along the high bank of the Ganges they go down as much as 50 feet in places.

The lifts in use are the *môt* and the *latha*. The latter is most commonly found near towns where they are chiefly used for watering garden crops.

There are six Court of Wards' estates, the villages of which are situated in all the four subdivisions of the district. But excepting Maghra in the Barh and Bihar subdivisions, which has recently got out of debt, they are reported by the Collector to be too deeply encumbered at present for the introduction of any improvement in the matter of artificial irrigation. Government estates number 55 and comprise an area of nearly 65 square miles, most of which is *diara* land lying along the banks of the Ganges, and not in need therefore of artificial irrigation.

GAYA.

General description.—The general aspect of the district is a level plain with low hills and jungle all along the southern boundary from where there is an easy slope towards the Ganges in the north. The northern half is flat, well irrigated and fertile, whereas the southern portion is thinly populated and indifferently cultivated. There are several rivers which run almost parallel to each other from the south to the north dividing the district into a series of high lands with river basins between. The soil is for the most part alluvial, from one of a stiff clayey character to that of a light sandy nature.

Rainfall.—The normal rainfall is low in Gaya. In the latest reports, the district shows a normal fall of only 42·96 inches which is much below that of Patna. This is a fact which has to be borne in mind in considering the necessity for irrigation in Gaya, especially as the slope of the country and the nature of the soil render it unretentive of moisture. The variations in the fall from year to year may be gathered from the following statement :—

Year.	Actual fall in inches.	Year.	Actual fall in inches.
1896 ...	35·25	1901 ...	36·32
1897 ...	53·43	1902 ...	38·65
1898 ...	51·19	1903 ...	29·59
1899 ...	50·54	1904 ...	49·77
1900 ...	35·32	1905 ...	51·23

The figures indicate variations similar to those of Patna.

Population, material condition, emigration.—At the time of the last Census, the total area of the district stood at 4,712 square miles, with a total population of 2,059,933 souls, which gives a density of population of 437 persons per square mile. This is much less than that of Patna. The agriculturists, who are returned as 1,311,229 persons, constitute 63·6 per cent. of the total population, and show a density of 440 persons to every square mile of the net cropped area (2,980 square miles) which is the lowest figure for Bihar.

Famine, scarcity, drought, &c.—Gaya cannot be said to be totally free from famine. The tracts most liable to famine lie along the south of the district comprising the hilly portion of the country. The western strip is protected by the Patna canal, and the country round about Gaya is more or less secure from famine. The chief cause of famine in the district is drought. The normal rainfall is low, and whenever there is a deficiency of rain, scarcity or famine is possible in the unprotected parts of the district. *Pains*, *ahars* and wells give a good supply of water, but they are insufficient to counteract the effects of a prolonged drought.

Cultivation.—The net cropped area of Gaya is 63·2 per cent. of the total area of the district, which is much lower than in the case of Patna and Shahabad. There is no doubt, that with proper provision for irrigation, much of the present uncultivated lands consisting of extensive tracts of culturable jungle could be brought under the plough.

Rice occupies 63·1 per cent. of the net cropped area. The *rabi* crops occupy only 38·58 per cent. of the cultivated area, and are therefore much less important in this district than rice. There is thus ample scope and urgent necessity for their development. With the extension of well irrigation, the *rabi* area would increase, and would place a larger quantity of food grains within the reach of the people. The *bhadoi* crops, inclusive of rice, take up only 8·62 per cent. of the cropped area. Sugarcane and opium are more largely cultivated than in many other Bihar districts, but there are places where their cultivation may still be further extended with the help of well irrigation.

Irrigation.—A strip of the western portion of Gaya, east of the river Punpun, comprising a small portion of the district, is protected by a branch of the Sone canal. The irrigational conditions of the rest of the district need only be considered in this report. In this portion, the sources of irrigation are *ahars*, *pains*, tanks and wells. *Ahars* and *pains* constitute the most prominent method of irrigation. They have been constructed chiefly for rice cultivation, but they answer another purpose when they dry up, as their beds retain sufficient moisture for the cultivation of good *rabi* crops. The extent of such *rabi* cultivation must naturally be limited. Irrigation from wells is comparatively insignificant in Gaya. Further north, the percentage of well irrigation gets higher. The northward slope of the country increases towards the south, and the water-level consequently gets lower, which in its turn makes well irrigation rarer. Temporary wells are more common than permanent wells. Most of them, whether permanent or temporary, are fed by percolation. There are some which are supplied from springs.

Gaya comprises three distinct classes of lands, each having its own requirements of irrigation. There are first of all the river beds, with strips of lands between them, which gradually rise from both sides to the centre. These are the *tanr* or uplands of the district. They are not suitable for rice, and are sown with *rabi* and *bhadoi* crops of different kinds, without any irrigation whatever. Well irrigation is not considered with favour for these parts on account of the cost of excavation and construction. The water level is low, and the depth of permanent wells is sometimes as much as 40 feet or 60 feet. The average depth of wells in the district to spring level varies from 50 to 35 feet. Lower down, the slopes and nearer the river, the lands are suitable for rice as well as for *rabi* crops. The rice lands are irrigated altogether from *ahars* and *pains*, and as this crop forms about 63 per cent. of the net cropped area, and is the staple food crop of the people, adequate provision by this method of irrigation must be given the first consideration. But *ahar* irrigation is now insufficient for the rice crop, and this deficiency is due to the disrepair into which *ahars* have fallen. It is not for me to suggest any remedy for this evil, after the sufficient and complete evidence given on the subject before the Irrigation Commission. I would, therefore, turn my

attention now to the *rabi* crops and to their extension. On the lower slopes, very excellent *rabi* crops are grown with the help of well-irrigation. Sugarcane and poppy are prominent also among special crops, and the extension of well irrigation must lead to good results. Water is found at a depth of 12 to 20 feet, and wells, therefore, do not require to be sunk very low. Both *pakka* and *kachcha* wells would be useful here. As there are some soils in the district, which sink in, *kachcha* wells in some instances will require to be protected by a lining of twigs or of earthen rings. *Pakka* wells should not exceed a cost of Rs. 250; they could be constructed even at a smaller expenditure in some places. *Kachcha* wells can be dug at a nominal cost. Where rock is found, as is occasionally the case, the cost of digging would naturally be increased.

I would specially recommend the digging of wells in what are locally known as the *dikans* lands, i.e., the lands near village sites. The extension of well irrigation in them, which may spread gradually further from the villages, would, as it has done in the Eastern districts of the United Provinces, not only give better crops, but extend the *rabi* area.

At present, although the *rabi* area constitutes 38·58 per cent. of the net cropped area, a very small proportion of it is irrigated from wells. What that exact proportion is, is not known, owing to the want of statistics, but a tour though the district will show that the only crops which receive well water are sugarcane, poppy, vegetable and garden produce and, to a very small extent, barley and wheat. The latter two crops would be the first to show marked improvement by the extension of well irrigation.

The methods of drawing and distributing water are the same as in other Bihar districts. The lever is more common than the *mot*, though the latter is to be seen more frequently than in North Bihar or Chota Nagpur.

It will be instructive to reproduce here some irrigation figures from the Final Report on the Survey and Settlement Operations in the Tikari Wards' Estate, the Government Estates, the Belkhara Mahal, and the Maksudpur Estate.

In Tikari, with an area of 389 square miles cadastrally surveyed, it would appear that as much as 41·2 per cent. of the net cropped area is irrigated. Of this, 12·5 per cent. only is irrigated from wells, 27·8 per cent. from canals and *pains*, and 55·9 per cent. from *ahars* and tanks. Although very much was done in Tikari in the matter of irrigation while it was under the management of the Court of Wards, there can be no doubt that much can yet be done to extend well irrigation in the estate. The percentage of well irrigation is low. There is much land that is suitable for *rabi* cultivation and for the sinking of wells. It has not been found possible by me to specify the particular *parganas* in which the sinking of wells should be undertaken, but the general remarks made above as to lands suitable for the purpose in the district would apply equally well to Tikari.

The Government Estates in Gaya, which have been cadastrally surveyed, contain an area of 102 square miles. The state of irrigation in this tract is given in the sub-joined statement, which has been compiled from the figures obtained by me from the Settlement office of the district :—

GAYA.	Total area.	Net cropped area.	Per cent. to total area.	Total irrigated area.	Per cent. to net cropped area.	SOURCES OF IRRIGATION.												NUMBER OF WELLS.	
						Irrigated from wells.	Per cent. to net cropped area.	Per cent. to total irrigated area.	Irrigated from private canals.	Per cent. to net cropped area.	Per cent. to total irrigated areas.	Irrigated from tanks and <i>ahars</i> .	Per cent. to net cropped area.	Per cent. to total irrigated area.	Irrigated from other sources.	Per cent. to net cropped area.	Per cent. to total irrigated area.	Masonry.	Earthen.
	Acres.	Acres.		Acres.		Acres.			Acres.			Acres.			Acres.				
Khas Mehals of Gaya district, comprising Ethil, Jarrah, Dakluner, Pachrukhi, Maher, Roh Sanant, Sherghati and Samal.	65,273·72	26,395·82	40·45	12,812·61	48·54	1,781·74	6·75	13·90	3,591·35	13·60	28·04	5,084·55	19·26	39·68	2,398·58	9·03	18·71	222	250

In the area comprised in the above table, the amount of land irrigated is 48·5 per cent. of the net cropped area, of which 13·9 per cent. is irrigated from wells, 67·62 per cent. from *ahars* and channels, and 18·7 per cent. from other sources. Canal irrigation does not extend to these estates. The three parganas which form the main portion of the estate are Sherghati, Dakhner and Jarrah. Of these three, it is reported that Dakhner is the best cultivated. The percentage of cultivated area that is irrigated (48 per cent.) is highest in Dakhner.

The corresponding percentages in Jarrah and Sherghati are 34·3 per cent. and 18·4 per cent. In the matter of well-irrigation, Jarrah however stands the highest with a percentage of nearly 40 per cent. The figures of percentage of well-irrigation to total irrigation in Dakhner and Sherghati are 9 and 1·6, respectively. It is stated in the Settlement Report, from which the above figures have been taken, that in Sherghati there is no hope for well-irrigation, but that much could be done for its development in Dakhner. With the construction of more wells, the cultivation of poppy and sugarcane could be extended. The land is especially suited to the latter crop.

The Belkhara Settled *mahal* covers an area of 91 square miles. Although a large proportion of this area is protected by the Sone Canals, irrigation from this source is limited to 29·6 per cent. of the irrigated area. *Ahars* and channels irrigate 53·2 per cent., and wells only 14·7 per cent. of this area. The figures above show that in this *mahal* also much remains to be done in the matter of well-irrigation. Its general conditions are such as suit the sinking of wells.

In the final report of the Settlement of the Maksudpur estate, which covers 130 square miles, 61 per cent. of the cropped area is shown as irrigated, of which well-irrigation accounts for rather less than one-seventh; tanks and *ahars* one-third, and the balance is irrigated from other sources. A field appears to me to be open for the extension of well-irrigation in this Raj also.

The Collector reports that in Government estates, irrigation wells are constructed every year. The figures quoted above from the Settlement Report show that the work decidedly requires further development at Government expense.

SHAHABAD.

General description.—The north of the district, comprising about three-fourths of its area, is altogether alluvial like the Trans-Gangetic districts of Bihar, but the remaining fourth in the south contains hills branching from the Vindhya range, in the midst of which is situated the Kaimur plateau. The district practically lies between the Ganges on the north and the Sone on the south-east. In the extreme north runs a strip of lowlying land, which receives its silt from the Ganges and grows good crops. The rest is made up of light loamy soils or of heavy clay lands. There are patches also of a dark argillaceous clay known as *karail* which grows *rabi* crops without irrigation but which cakes and becomes useless for cultivation in the hot weather. The soils of the district are generally much drier than those of the Trans-Gangetic districts of Saran, Champaran, Muzaffarpur, Darbhanga—hence the greater necessity of irrigation.

Rainfall.—The district normal rainfall differs very little from that of Gaya. It measures 43·65 inches, which is about two inches less than that of Patna. The variations which occur in the actual fall from year to year are given in the subjoined statement, which quotes the rain received for the last ten years:—

Year.		Actual fall in inches.	Year.		Actual fall in inches.
1896	...	30·85	1901	...	34·54
1897	...	49·09	1902	...	40·43
1898	...	47·53	1903	...	34·18
1899	...	57·15	1904	...	47·06
1900	...	44·03	1905	...	46·51

The variability in the fall is the same as in the rest of South Bihar.

Population, material condition, emigration.—The total population is less than that of Gaya, but more than that of Patna. In 1901, it was 1,960,696 which, with a total district area of 4,373 square miles, gives an average of 449 persons per square mile—a density much less than that of Patna. The agriculturists, who number 1,252,451 souls, form 63·8 per cent. of the population, which is practically the same as Gaya, but slightly more than that of Patna. The average number of agriculturists to every square mile of cultivated land (2,586 square miles) is 484, which shows a density much less than that of Patna. Yet it is reported that the district does not suffer from want of labour for agricultural purposes.

Famine, scarcity, drought, &c.—The land lying to the north of the Grand Trunk Road is now free from famine owing to its system of canal irrigation. To the south of this road, the entire tract, consisting of the major portions of the Bhabhua and Sasseram subdivisions, is more or less liable to famine, and here it is that the system of well-irrigation requires to be developed.

Cultivation.—The net cropped area, comprising 2,586 square miles, forms 59·14 per cent. of the total area of the district. This proportion is lower than the corresponding proportions in Gaya and Shahabad. Rice is a more important crop in Shahabad than in the rest of South Bihar; the *rabi* area is noticeably more insignificant, and sugarcane cultivation is more advanced. The proportion of the net cultivated area these crops occupy in the three districts of South Bihar are as follows:—

DISTRICT.	PERCENTAGE TO NET CROPPED AREA.		
	Rice.	Rabi.	Sugarcane.
Patna ...	45 29	42·70	1·84
Gaya ...	63 16	38·58	1 57
Shahabad ...	71 27	24·30	2·11

The figures tend to point to the desirability of extending that system of irrigation which may lead to an increase of the *rabi* harvest. Sugarcane also makes its demand upon well water, the increase in the supply of which would undoubtedly result in the larger cultivation of the crop, especially when the soil in different parts of the district is admirably adapted for such cultivation. Opium does not seem to be as highly cultivated in Shahabad as in other parts of South Bihar. Wells are to be found, however, wherever the crop is grown. The well-irrigated area of the crop is now reported to be increasing annually and it may similarly be increased for other crops, which also derive benefit from well water.

Irrigation.—Wells are most largely used for irrigation in the Sasseram subdivision. In an official report, perused at the head-quarters of the subdivision, I found it stated that 66½ per cent. was the approximate proportion of the area irrigated from wells to the total irrigated area of the subdivision. Wells are commonly used by *Koeris* near towns for the cultivation of vegetable and garden produce, and they are to be found wherever opium is grown. The Grand Trunk Road, which traverses the district from west to east, divides it practically into two distinct portions, as regards their necessity for irrigation. The largest portion of the Buxar and Sadr subdivisions and that portion of the Sasseram subdivision which lies north of the Grand Trunk Road is commanded by canals. Wells, therefore, are not ordinarily necessary for irrigation in this tract. But almost in the whole of the Bhabua Subdivision and in that part of Sasseram which lies to the south of the Grand Tank Road, wells are rare. They may well be extended in Sasseram, as wherever they occur, they are much appreciated. They are used for different kinds of *rabi* crops, for sugarcane, poppy and vegetables.

The water-level varies from 30 to 40 feet, although in some places water may be found at a depth varying from 15 to 20 feet. The soil is generally suitable for well-sinking, and both *kachcha* and *pakka* wells may therefore

be dug. The cost of the former kind of wells is estimated at Rs. 2 to Rs 7, and of the latter from Rs. 200 to Rs. 300. Wells in Sasseram should be commenced first within a radius of 6 or 7 miles of head-quarters, *i.e.*, till the jungles are approached. The work should not be stopped here altogether. It is true, that the villages begin now to get scarce and the population sparse and cultivation limited, but it is really the want of irrigation that is the cause of the poor cultivation of these parts. In the Kaimur plateau, at least, some borings may be made. Wells should be sunk in existing villages on this plateau and their construction should gradually spread from these centres. The water-level of course is deeper on the plateau than elsewhere, being reported to be about 45 feet below the surface.

In the Bhabua subdivision, wells are not as popular as in Sasseram, but their working is not unknown. Wells, both *pakka* and *kachcha* exist, and are used only to a small extent for sugarcane, poppy and vegetables, but no reason was adduced by cultivators against their extension for *rabi* crops generally. There is in my opinion very great scope for irrigation all over Bhabua.

Mots, as well as *dhenkats* are worked in the district, so both large permanent and small temporary wells may be recommended in all parts south of the Grand Trunk Road.

The District Officer of Shahabad is of opinion, that the chief difficulty in extending well-irrigation will be the dislike of cultivators to the incessant labour involved, but such a difficulty does not appear to me to be insurmountable. It would disappear, when the cultivator finds that the extra labour involved brings in an addition to his yearly income.

Government is in a position to develop the work directly. There are 145 Government estates in the district, and if money were allotted, the Collector thinks that well-irrigation could be extended in a fairly large number of estates. The amount now allotted, he considers insufficient, even for the upkeep of the existing wells and *ahars*. Wells constructed in Government estates would always act as object lessons to other neighbouring cultivators.

CHAPTER VI.

Takavi advances—(a) *United Provinces*.—In Ghazipur, as in the United Provinces generally, *takavi* advances are given under the Land Improvement Loans Act for the construction of *pakka* and *kachcha* wells, *kachcha* tanks and *bunds*. On receipt of an application for an advance, enquiries are instituted through the Tahsildar ascertaining the feasibility of the proposed improvement, its probable cost, the area and kind of land to be benefited by it, the right of the applicant to make it, the security he can give for the due application and repayment of the loan, the instalments (if any) in which the loan should be advanced, the instalments by which it should be made repayable, and any other particulars which are to determine whether or not the loan should be granted. The cost of improvement is not set forth in the application, nor is any attempt made to estimate the cost by the officer deputed for the enquiry. The report of the Tahsildar is submitted to the Collector, who after approval, signs the Treasury order for payment and sends it to the Sub-Treasury Officer (who is generally of the rank of a Sub-Deputy Collector of Bengal) for disbursement of the advance to the payee. As a rule, advances are not made in instalments, and not taken collectively. The securities taken are of a permanent character, *viz*:—

- (a) *Zamindari* from landlords, otherwise on hypothecation of landed property by others.
- (b) Fixed rate tenures from tenants, otherwise on hypothecation of landed property by others. Well-to-do tenants often stand as security for the poor tenants who apply for advances. The ordinary rate of interest charged is $6\frac{1}{4}$ per cent. per annum, but in the famine year of 1896-97, advances in some cases were given at $4\frac{1}{2}$ per cent. for masonry wells, and without any interest for *kachcha* wells. The period within which a loan,

together with interest chargeable thereon, is made repayable is generally limited to ten years and is never less than four years. Compound interest at $6\frac{1}{4}$ per cent. is charged upon all overdue instalments of interest or principal, or both, from the date of default.

Muhammadans, *Chattris* and other castes who usually employ outside labour mostly take advances for wells. *Koeris*, *Kurmi* and others who seldom have occasion to resort to outside labour, unless they have a very large area to irrigate, do not come forward for advances in such large numbers. They are moreover very industrious and energetic and grow valuable crops, so that they generally have funds at their command.

I have not been able to ascertain the actual amounts distributed for the construction of wells in different years. The largest advances were made in the famine year of 1896-97. It is reported that whenever such advances are made, they are readily taken by landlords and tenants alike, the relations between whom are reported to be fairly good. The landlords as a rule do not prevent tenants from making improvements, nor do they usually take any *salami* before letting their tenants execute improvements. The majority of tenants understand their rights and liabilities with reference to the matter of improvements. They therefore readily undertake them without any fear of enhancement of rent from the landlord. The landlords themselves also are not apathetic in the matter of effecting improvements for themselves.

(b) *Bihar and Chota Nagpur*.—In preceding sections of this report, I have attempted to show that well-irrigation undoubtedly requires to be developed both in Bihar and Chota Nagpur, and that taking into consideration the physical, economic and agricultural conditions of these two Divisions of Bengal there is also scope in them for such development. It is now my duty to point out how this work of improvement can be pushed on. Much of course would depend upon the interest taken in the matter by District officials. Agricultural improvements of all kinds moreover have generally necessitated assistance from Government. In the matter of wells, such assistance will be all the more necessary, inasmuch as in many districts, where it is desired that this work should be pushed on, serious difficulties arising from the conservatism and want of enterprise of the *raiyat* will have to be overcome. No doubt, some good may be effected by educating *raiyats* of backward districts as to how to dig good wells in suitable places, but they will not be persuaded to undertake the work unless they get some kind of pecuniary encouragement from Government, and this can only be given under the system already in force by which advance of loans is made from State funds for agricultural improvements under the Land Improvement Loans Act of 1883, and under the Agriculturists' Loans Act of 1884. From the experience, I have gained during my tours, I am of opinion that *raiyats* would be willing to take such loans for wells readily, if only, they could get them with less trouble and less harassment than they experience in taking *takavi* advances at present. The existing procedure appears to be such, that *raiyats* in many cases prefer taking loans from *mahajans* to taking them from Government, even though they have to pay higher rates of interest. This uneasiness on their part must be overcome at the very outset, by making the system of advances as simple and as liberal as possible. On this point, all District Officers who have very kindly given me their opinion on the subject, are unanimously agreed. Mr. Egerton, I.C.S., the Collector of Darbhanga, has very strong views with regard to the simplification of the procedure regarding the giving of advances. He is of opinion that preliminary application for loans from *raiyats* are not necessary. He advocates a joint bond system with the village as a unit.

The one obstacle more than any other, which stands in the way of the popularity of the present system of advances, is the rule in both the Loans Acts, which requires the *raiyat* to go for his loan to the Collectorate or to the Subdivisional head-quarters. The trouble and expense of the journey is dreaded, especially when the *raiyat* lives far from the head-quarters of the district or subdivision. When eventually these head-quarters are reached, the *raiyat* finds that he has to part with some of his funds to unscrupulous underlings before he can get the advance for which he has applied. What is therefore required at the outset, after as wide publicity as possible has been previously

given by beat of drum, through village chowkidars and *panches*, of the readiness of Government to advance money, is that the people get the money distributed on the spot and without needless delay and the harassment of coming into head-quarters, where they are often kept waiting about on many pretexts, if they do not satisfy the several underlings through whom the money has to come to them. It would be well, if a Special Deputy Collector or Sub-Deputy Collector be employed for the distribution of these loans at the homes of the *raiyats* or from suitable centres. It would be his duty to go to the villages and use his tact and influence in getting people to take advances, to make the usual preliminary enquiries, to arrange all the signing of the necessary bonds, and then to disburse the money on the spot.

In my humble opinion, the other rules which are now followed by Government in making advances for agricultural improvements also generally need relaxation,—if well construction is to become popular—and especially must they be relaxed in those districts where well sinking is not in vogue.

Regarding the preliminary enquiries to be made and the security to be taken, I am unable to suggest any modification in the rules now in force. The joint personal security system seemed to receive the approval of many district officials, and may often be accepted in lieu of landed security, according to the discretion of District Officers.

In the matter of the rate of interest to be charged, I am of opinion that the scheme would not develop, if the same rate of interest, viz., $6\frac{1}{4}$ per cent. be charged for advances for wells as are now charged for ordinary agricultural improvements. The Opium Department owes its success in pushing on the sinking of wells, mainly to its taking no interest for advances given. With advances given by Opium officers 3,637 masonry wells and £4.127 earthen wells were constructed from 1895—1905 in the Opium districts, which comprised the following centres:—Tirhut, Chapra, Siwan, Motihari, Bettiah, Shahabad, Gaya, Tehta, Patna, Monghyr and Hazaribagh. During these ten years, the total amount advanced for well sinking and well repairs amounted to Rs. 35,960. I do not think in the matter of sinking wells for ordinary crops, the same concession can be shewn. The Opium Department has its interest in the poppy crop, which is served without making any charge for the advance given for the improvement of the crop. Government will not derive that direct interest from the improvement of ordinary crops, and it is just, therefore, that it should get some return for its outlay in loans. This need not be taken as profits by Government. The money could be utilized for the further benefit of applicants, who would be in need of special concessions. Therefore, while I am of opinion, that interest may reasonably be charged by Government, I think the present rate, although not excessive in itself, must be reduced, if the scheme is to become popular. I would therefore suggest that the general rate of interest be reduced from $6\frac{1}{4}$ per cent. to 4 per cent. I think such a reduction would have an appreciable effect in increasing the demand for loans for wells.

As regards the system of advances, it appears to me, that the example of the Opium Department may be followed. I am informed by Mr. Christian, Factory Superintendent, Bankipore, that advances for wells are usually given by the Opium Department in three instalments, commencing from January or February. Half of the total amount is given as the first advance to get the materials. The second advance, which is one-fourth of the total amount, is given after it has been ascertained that the necessary materials for construction have been collected and the remaining one-fourth is given for the completion of the work, when sufficient progress has been made in construction. It is very probable, that the *raiyats* would prefer to have the whole advance in a lump sum, and the system of instalments may entail extra labour on those entrusted with the distribution of advances; but I think, it would do much towards ensuring that the money is being spent solely on wells.

To go on now to the question of the repayment of loans by borrowers. It is generally thought that Collectors and Subdivisional Officers and other special officers authorized to distribute loans should be given more discretion about taking repayments in *kists*, and of allowing suspensions in

particular cases. The period of repayment may not be fixed absolutely. It should depend altogether upon the amount of the loan and the condition of the *raiyat*, and may vary ordinarily from two years for small to ten years for large loans.

As to the penalty to be imposed in case of failure of an instalment, the matter should again be left to the discretion of the distributing officer and his collector, who would be the best judges of what, if any, coercive measures should be taken against the defaulter.

The above remarks apply to advances to be given to *raiyats*.

It is a question how far the system can be developed by extending loans also to zamindars. There may be many cases, where tenants may be unable to take loans on account of their poverty, but where *zamindars* may be willing to accept such loans. In such places, advances may well be given to them. *Zamindars*, moreover, are in a better position to execute larger improvements than *raiyats*, and the more enlightened of them should undoubtedly be encouraged to take Government loans for sinking wells. From *bonâ fide* applicants, the realization of the advance should not be a matter of difficulty. A mortgage of their proprietary right in the village would be ample security. The fear in some cases would be, that the zamindars might levy a cess, or claim enhanced rent for the use of well waters from the *raiyats*, when they constructed wells at their own expense from the money obtained from Government. Government alone can restrict such rights. With regard to loans for wells, therefore, to *zamindars*, the District Officer again would be the best judge as to which *zamindars* in his district could be best trusted with such loans.

As regards the amount to be allotted by Government for loans, I must at once admit my inability to submit even an approximate estimate for the consideration of Government. Each district will have its own requirements in this respect and the District Officer, in consultation with the District Engineer, may be asked by Government to frame estimates based on the suggestions already made by me in previous paragraphs regarding the scope of well irrigation in each district. Sums of Rs. 5,000, 10,000 and 15,000 have been suggested to me by some District Officers as suitable allotments for their districts for the first year.

CHAPTER VII.

CO-OPERATION OF DISTRICT BOARDS, AGRICULTURAL BANKS, OPIUM OFFICERS AND PLANTERS.

District Boards.—District Boards have enough work already, and they cannot spare their officers for undertaking or supervising any work in connection with the sinking of irrigation wells. They are also unable to give any money for this purpose, as their provision for wells is fully absorbed for the supply of drinking water. Were their staff increased, they could be well utilized to help Government in extending the construction of wells.

Agricultural Banks.—These are still too much in their infancy to be of much service. Their resources are limited, and the capital small, and they cannot, therefore, be expected to grant loans for wells. There are many districts moreover in which Agricultural Banks have not yet been established.

Opium officers and planters.—The officers of the Opium Department could assist in ascertaining the needs of different districts and in stimulating local effort, but it is their work and interest to extend opium wells alone and it would be difficult therefore to enlist their services for the digging of irrigation wells, outside opium areas. Of course, if Government would increase the allotment for wells in this Department, their extension even in opium areas would open out their utility also for the cultivation of other crops.

Planters are generally willing to help Government in the extension of well irrigation, and their services in this matter may therefore be utilized by District Officers.

CHAPTER VIII.

TRIAL BORINGS.

Work done in the United Provinces.—For some years, special measures have been taken by the Department of Land Records and Agriculture of the United Provinces to train and maintain an expert staff to push on the work of making trial borings with a view to improve the water-supply from wells for purposes of irrigation. Much good work has been already done in this respect in that Province. In the quinquennium 1900—05, the number of borers increased from 8 to 19, and the number of borings from 83 to 251.

Even with this increase in the staff, the supply of expert labour was found to be insufficient for the demand. The local Director, Mr. W. H. Moreland, C.I.E., intends now to employ 40 borers in the Province and estimates that the total cost of maintenance, inclusive of the superior staff, will be about Rs. 20,000 annually.

The system of working adopted in the United Provinces is as follows:—The borers are trained by the expert staff of the Department, which consists of men brought from the Roorkee Engineering College, where in addition to their training as Public Works Overseers, they have also been specially taught the use of boring tools. There are four such men at present, whose maximum pay has been now fixed at Rs. 150 per mensem. The experts teach selected intelligent men the practical use of boring tools, and the services of these skilled workmen are subsequently lent to landlords and cultivators.

Description of tools and their cost.—As regards equipment of tools, the best description I can offer is that which appears in a leaflet of the United Provinces over the signature of its Assistant Director of Agriculture, and which is as follows:—

“Boring tools are divided into four parts, viz.—

(a) *Pipes and tools required for sinking.*

(b) *Loading apparatus.*

(c) *Extracting tools wanted when the pipes have reached the required stratum.*

(d) *Extractors wanted only when ropes break or portions of the pump are left behind.*

(a) *Pipes and tools consist of—*

Five pipes of 2 inches internal diameter and about 14 inches long each.

These are ordinary gas pipes and fitted with bevelled couplings.

One funnel of cast iron, which fits on to the top of the uppermost pipe and directs the pump or jumper to the mouth of the pipe.

One steel shoe.—This is fitted on to the lower end of the lowermost pipe and is provided with a cutting edge to pierce through the different strata met with.

One double pulley block, 5 inches, of galvanized iron. This is fixed in a tripod above the well, and the ropes attached to the pumps and jumper work over it.

Two pairs of tongs, so made as to hold the pipes firmly, when they are being screwed to or unscrewed from one another.

Four pumps.—These are worked at the bottom of the pipe by means of a rope passing over the pulley block.

One jumper.—This is used to soften and break the soil at the bottom of the pipe when the pump is found to make no impression.

One oil feeder provided with oil to lubricate the joints and screws.

(b) *The loading apparatus includes—*

One wrench.

One weight clamp.—This is in two pieces divided vertically, is of cast iron, and is fitted with four bolts. It is tightened on to the pipe by means of the above wrench.

Four weights.—These are of cast iron, are in one piece, and are put on over the mouth of the pipe, first taking the funnel off. They rest on the clamp and add to its weight, thus assisting the sinking of the pipes.

(c) *Extracting tools made of—*

Two clamps each 3 feet long, in two pieces, fitted with bolts and made of wrought iron. They are clamped on tightly to the pipe by means of a wrench.

One small wrench.

Two screw jacks, 5 tons, Haley's. The wings of the above clamp are rested upon the top or on the stirrups of the jacks.

(d) *Extractors* consist of—

70 *Running feet* of $\frac{3}{8}$ inch gas piping.

1 *Spring extractor*.

1 *Hook extractor*.

“These tools are useful only in case of accident. The rope may break, leaving the pump or jumper at the bottom of the pipe, or the bottom valve pump may be left behind, or the upper valve and piston may come away, leaving the tube behind, or the piston rod may break, leaving the tube behind. In either case, the piece so left can be extracted by means of the above tools.

“Each set of tools can bore to a depth of 65 feet to 68 feet below water level, if necessary, but for an 8-feet well it is not advisable to bore below 52 feet or for a 6-feet well below 42.

“If clay is not found within this distance, the pipes should be withdrawn. If clay is reached, the pipes should be sunk 3 feet or 4 feet into it to ascertain whether the stratum is hard and thick enough to form a good foundation and support the cylinder.

“The cost of boring varies so much with the soil met with that no estimate can be framed, but Rs. 5 for a boring on sand to Rs. 20 in clay or *kankar* should be quite sufficient.”

The cost of each set of tools inclusive of freight may be estimated at about Rs. 500.

Well boring in this Province.—The utility and advantage of making trial borings in this Province, and of maintaining an expert staff with an adequate equipment of tools cannot be doubted. In the United Provinces, it is no longer a question of experiment; and there is no reason why the success, which has attended well boring in those Provinces, should not be attained in Bihar where conditions are similar. In a recent letter to Government, Mr. C. A. Oldham, I.C.S., the Director of Agriculture of this Province has anticipated me in pointing out that it is “not only in the alluvial tracts that trial borings will be of value, but on the lower slopes, and at the foot of the hills. In many districts in this Province, it may be possible by boring, to tap an artesian supply or find a constant flow of water beneath surface layers of rock or impermeable strata.”

The question now to be considered is.—To what reasonable extent can the work be undertaken in Bengal by Government. In the United Provinces, Government is assisted to a great extent by landlords who apply for the services of skilled borers. The landlords pay the trained workman his salary and his travelling expenses; they find the labour needed, pay for the freight of the tools, and bear the charge for all contingent expenses. In this Province, all charges would fall upon Government. An estimate recently made by the Director of this Province inserted below, shows what this cost may be at first.

The estimate relates to the districts of the Patna and Bhagalpur Divisions (excepting Darjeeling, where wells are of no importance for irrigation) and provides also for one supernumerary borer to fill vacancies caused by illness or leave. It is not to be understood here, that I do not advocate well boring for the districts of the Chota Nagpur Division, which have been visited by me. I have pointed out in my notices of these districts that *ahars* and other artificial channels play a most important part in their irrigation, and have drawn attention to the necessity of developing such sources of irrigation, but at the same time well-irrigation in these parts is not to be lost sight of. What I wish to submit is, that in every new undertaking, it is wise to move with caution, and that I would therefore defer trial borings in Chota Nagpur only till sufficient experience has been obtained in districts more favourably situated for well construction.

Estimate of cost of plant and staff for well boring.

	Rs.
(I) Capital outlay—	
Price of 12 sets of tools, inclusive of freight, at Rs. 500 each set ...	6,000
(II) Recurring charges—	
1 Expert on Rs. 100 to Rs. 150 per mensem,	
Rs. 1,200 to Rs. 1,800 per annum,	
12 Borers on Rs. 15 to 20 per mensem,	
Rs. 2,160 to Rs. 2,880 per annum,	
Travelling allowances about Rs. 2,000 per annum.	
Cost of annual repairs and renewal of 12 sets of tools at Rs. 50	
per set.	600

The initial cost would thus be about Rs. 6,000 and the annual recurring charges would amount to another Rs. 6,000 in round figures.

For the above work, it will be necessary to get a trained Roorkee expert. The Department of Agriculture of the United Provinces may perhaps be induced to lend us the services of one of their four men, till we are able to get a suitable man.

Each set of tools would be kept at the head-quarters of the district, from where it would be given out on loan, as necessity arises.

It would be in charge of a borer, who would work under the direct orders of the Collector.

The District Engineer would perhaps be able to help in directing and scrutinising the work of the borer, and in reporting progress of work through the Collector to the Director of Agriculture.

N. N. BANERJEE,

Department of Agriculture, Bengal.

APPENDIX.

Composition of well water in different districts.

	GHAZIPUR.		BALLIA.	GORAKHPUR.	SARAN.	DARBHANGA.	MONGHYR.				BHAGALPUR.
Potassium nitrate	0'833	1'66	2'08	1'667	1'670	...
Calcium do.	...	Nil.	75'5	Nil.	Nil.	2'0	...	18'710	45'08	10'342	17'660
Potassium sulphate
Magnesium do.	37'8	...	...	1'5	...	28'88	34'05	11'348	18'570
Do. carbonate	...	15'1	44'7	17'4	4'5	7'7	12'874	1'080	...	2'362	...
Calcium do.	...	10'0	9	17'0	16'0	31'9	15'000	31'600	20'52	25'69	27'760
Sodium do.	...	43'9	...	5'7	1'3	...	9'726	...	...	...	10'52
Calcium chloride	2'770	...
Magnesium do.	12'710	14'98	20'86	34'060	...
Potassium do.	...	15'4	11'9	Nil.	6	6	...	...	...	...	...
Sodium do.	...	7'3	49'5	2'7	18'5	8'4	4'234	17'62	18'96	...	3'81

	SONTHAL PARGANAS.		RANCHI.	PALAMAU.	PATNA.	GAYA.		SHAHABAD.
	Dumka.	Kalikund.	Sadar.	Daltonganj.	Bankipur.	Pakka well.	Kachcha well.	Bhabhua.
Potassium nitrate
Calcium do.	11'24	...	...
Potassium sulphate
Magnesium do.	2'06	4'64	3'09	5'67
Do. carbonate	...	2'27	...	5'28	12'19	4'32	5'41	7'39
Calcium do.	...	2'00	...	1'00	15'00	26'00	30'16	30'00
Sodium do.	...	2'77	10'07	5'14	13'45	5'91	2'86	4'00
Calcium chloride
Magnesium do.
Potassium do.	6'14	3'99	2'76	...
Sodium do.	...	2'12	2'12	1'06	2'75	15'72	23'33	18'37

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